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THE HAWAIIAN PLANTERS' RECORD

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A quarterly paper devoted to the sugar interests of Hawaii and issued by the Experiment Station for circulation among the Plantations of the Hawaiian Sugar Planters' Association.

Report of the Committee on Irrigation*

BY J. S. B. PRATT, JR.†

The Chairman of the Irrigation Committee has had the opportunity during the past year of visiting the different plantations, and in presenting herewith a report of the developments in irrigation for that time reports largely from personal observations. The material will be discussed under various subtopics.

OVERHEAD IRRIGATION

The greatest development of the year is overhead irrigation. The writer has prepared a detailed report, of the system installed at Hawi, which will appear in the next Record. For the benefit of discussion among our members, a brief summary is given. Manager Henry Hind very kindly supplied available data.

Overhead irrigation is not new in the Islands. Quite a few in Hawaii have tried the Skinner system of overhead irrigation for alfalfa patches, vegetable gardens, etc. A number of years ago (1915-1916), the late A. W. Collins tried an area of sprinkler irrigation for sugar cane at Paia. Maui Agricultural Company decided at the time that the cost was exorbitant, the winds giving an unequal distribution, and the cost of irrigating being higher. Being on such a small test (2-acre plots), naturally the cost would run higher. Very much less water was used, but the tonnage was smaller. The experiment was discontinued. About six years ago, B. D. Baldwin of Makaweli laid out an area of a few acres in an overhead sprinkler system.

The difference between the Skinner system and the overhead systems of Hawi and Makaweli is that the Skinner system has horizontal pipes over head with small jet nozzle openings, possibly two feet apart, for the water to spray out. The overhead at Hawi and Makaweli has vertical standpipes set certain distances apart with sprinklers on the top. The disadvantage of the Skinner system is that it is believed that the small openings would clog readily, and one can see the difficulty of getting at these horizontal overhead pipes above the cane.

* Presented at the second annual meeting of the Association of Hawaiian Sugar Technologists, Honolulu, October, 1923.

† Chairman, Irrigation Committee.

The Makaweli overhead system was laid out in an old ratoon field near the manager's house and the government road. The standpipes were 25 feet high, guyed with 3 stay-wires. They were set 80 feet apart, but Manager Baldwin says that 60 feet would be a better distance. The nozzles used finally, after trying many, were the geared type, costing about \$14 apiece. This would take about 8 per acre, a rather expensive item. The field being laid out previously in the old style, there could be no cultivation by animals, which is one of the chief advantages to the system. The field raised good cane, and would be continued with the overhead system except that it is too old a ratoon field and must be plowed. Another small layout was made some little time ago on a dry pali nearby.

John Hind at Hawi has tried overhead irrigation for several years on a small plot. This year he has gone past the experimental stage, and already a field of 100 acres is in, with another of 88 acres to be planted as soon as the balance of the pipe arrives. Next year, possibly, another 250 acres will be planted to it. One has only to look at the system working and compare the fields laid out under the old style with that of the new, to see how well it fits Hawi's conditions. The writer sees places where it may possibly work to advantage, but one knows that it would be too expensive a proposition for some, and not adapted for others. But Hawi has a porous soil, a shortage of water, and at many times, a labor shortage.

To illustrate how the system is laid out suppose we take an even field with gentle slope, the greater the slope the better the "head" of course.

First we have our main line running with the slope. We will have to go back to get enough "head" or pressure, or as Hawi is doing on its new field, put in a pump to give us enough pressure, say 40 lbs. per sq. in. A pressure gauge helps us determine this practically. From our main line of say 6" pipe, we run off laterals to right and to the left every 56 feet. If we plant our cane 4 feet wide, we have 14 lines of cane between our laterals. On our laterals we place our standpipes vertically, every 60 feet. The height of these standpipes varies for locality, Hawi's cane being short and the wind favorable, 10 feet is the height of the pipe used there. Our laterals should not be much over 400 feet long. They should come off at right angles, for a perpendicular would be a shorter line than a diagonal. The reason we take 60 feet is because the 20-foot lengths of pipe do not have to be cut.

We reduce our main line as our pressure becomes greater, and as our friction increases. The laterals will probably start at $1\frac{1}{2}$ " in diameter, reduced to $1\frac{1}{4}$ " to 1" to $\frac{3}{4}$ ". The standpipes are $\frac{3}{4}$ " reduced to $\frac{3}{8}$ ". The sizes of our pipes vary according to our conditions, depending on the amount of water we want to give in a certain time.

The sprinklers used at Hawi are made in the shop, costing 45 cents apiece. They are in two parts and the upper portion can be lifted off by the use of a stick in big cane and the pressure will blow out small cloggings. Hawi screens all the water entering. The layout for each field differs. A contour map gives one the necessary data, and the system can be figured out in the office as to what pipes are necessary, etc.

Without going into further details of the system, the following advantages and disadvantages may be considered.

ADVANTAGES OF OVERHEAD SYSTEM

- (1) *Water Regulation:* Any amount of water may be given, 1 inch or 5 inches, largely depending upon the time applied.
- (2) *Water Saving:* Hawi expects a saving in water. "Old" style 1,300,000 gallons per day for 100-acre field; "overhead" only 750,000 gallons, but no actual data from measurements. Paia's sprinkler system took less water. No seepage from ditches, but more evaporation.
- (3) *Cultivation:* Cheap cultivation. Unirrigated conditions. Very little hand hoeing.
- (4) *Mulch Control of Moisture:* After irrigation, cultivation can give mulch, at same time get small grass.
- (5) *Water Immediately After Harvesting:* This is a most important consideration, and a reason why such sensitive canes as H 109 have failed to ratoon well on some places.
- (6) *Labor Saving in Cultivation and in Irrigation:* The Paia system showed no labor saving, but it was on a two-acre piece. The man at Hawi hoes nearly all day long. At Hawi, one round is made on the 100-acre field in 7 days, or 14 men total, one day and one night man. Under the old system at least 120 men would have been needed.
- (7) *Fire Protection:* Very apparent.
- (8) *Hoeing:* Less weeds through animal cultivation. Less weeds from dirty ditches, etc.
- (9) *Area Saved:* Saving in acres taken up by ditches, water courses, etc.
- (10) *Harvesting:* Simplified by straight lines.
- (11) *Day and Night Irrigation.*
- (12) *Fertilizer Action:* Not delayed by lack of proper moisture.

DISADVANTAGES

- (1) The cost, \$150 to \$200 per acre, depending on individual layouts.
- (2) Sprinklers may not start well. Some may clog later from accumulation.
- (3) Evaporation loss, and loss through some water not getting to root through trash and heavy cane, compensated somewhat by less ditch seepage losses.

A study of soil moisture and growth measurements of both the overhead system and the old contour layouts will be a most interesting one, and next year, we should have more to report. The overhead system is one of the most interesting developments in irrigation for some time, for it offers possibilities for certain plantations short of water, and having a very porous condition of soil.

ORCHARD SYSTEM

One small area has been harvested at Ewa, but a further trial is desired before discussion.

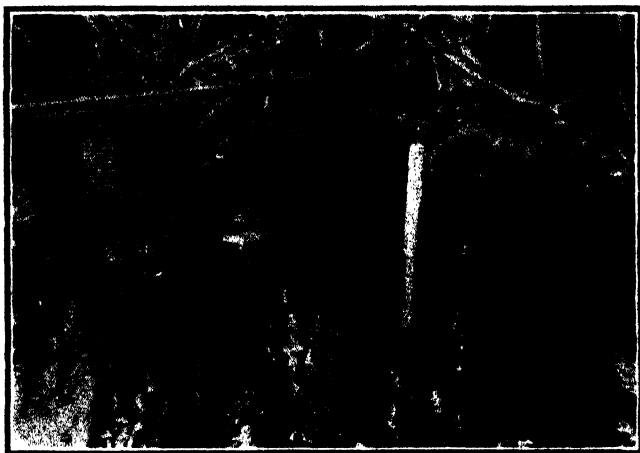
Kilauea harvested its first areas. Figures are not available, and should not be used for comparison as the original area was not a fair test with the rest of the field, the balance of the field having mud press, and the "long line" area none. The writer visited this area, now on first ratoons, about a month ago, and it was ratooning fully twice as well as the rest of the field, as irrigation water could be

given quickly and cheaply immediately after harvesting, weeds being kept in check by cultivation, etc., while the rest of the field simply could not be cared for by the contour system, due to labor and water shortage.

Koloa should harvest a very comparable area of about 25 acres each on the orchard system and contour system next year.

The system seems admirably adapted to semi-irrigated conditions, where cultivation is possible and an insurance given for a quick irrigation when water is available.

Last August, Oahu Sugar Company put in a nine-acre test of the "Orchard" system against the "Peru" system, against 32 feet and 40 feet water courses of the older systems. Manager Thomson of Oahu Sugar Company very kindly supplies the following data. When the area is harvested next year, very valuable data may be obtained. The actual water going on each system was measured by use of a rectangular weir.



The Orchard system of 9.02 acres, averaged for 10 irrigations, 140, 195 gallons per acre per irrigation, or 5.2 acre inches.

The Peru system or units of 4 long lines as in the Orchard system, of 2.98 acres, averages 225, 150 gallons per acre per irrigation for 9 irrigations, or 8.2-acre inches.

The 32-foot wide watercourse requires the least amount of water on a 6.38-acre piece, averaging 81,705 gallons per acre per irrigation, or 3.0-acre inches.

The 40-foot watercourse on a 3.08-acre piece averages for 11 irrigations, 90,780 gallons per acre per irrigation, or 3.3-acre inches.

The cane in the old style is planted 5 feet apart, in the Peru and Orchard systems $4\frac{1}{4}$ feet apart. There appears to be more sticks in the Orchard system though smaller in diameter. No area is taken up by water courses. The Peru system has more area taken up by level ditches.

To date then, with cane one year old, the narrower water course on the old contour system, one line irrigated at a time, requires much less water. More area is devoted to water courses per acre. However, the final test comes at harvesting next year, when the sugar per unit of gallons of water used is figured. It is too soon to draw conclusions, aside from the fact that the Orchard system for Waipahu conditions is requiring more water than was anticipated.

ORCHARD SYSTEM AT MAKAWELI

This area planted for the 1923 crop by Manager B. D. Baldwin, consisting of some 5 acres, was harvested recently and Manager Baldwin states that the "long" line area yielded 7.7 tons sugar per acre, that the "old" style went 7.3 tons sugar per acre for the rest of the field. Here the slope was average, the soil red loam towards silt, and not the porous soil giving lateral percolations at Kilauea. The area at first was irrigated once in ten days, but as the cane became more mature, it required more irrigation. Finally, it required a daily irrigation, but Manager Baldwin believes with a total amount not in excess of the 14-day period which the rest of the field was getting. No actual water measurements were obtained. The ratoons are now up two feet, of excellent stand. They will be irrigated twice a week consistently. The system yielded much better than was expected.

The optimum distance between level ditches on the Orchard system is between 250 and 300 feet.

BALDWIN FLUME SYSTEM

At the time of the writer's visit at the beginning of the year, the field of about 30 acres in the Baldwin flume system had just been harvested. Then Acting Manager Nicoll told us that the yield was not very satisfactory. Looking at the field one should not blame the system entirely for it is a rather uneven field for a test. A field of some 50 acres for the 1924 crop will give good data next year. No more new areas are being laid out.

WAIPIO SYSTEM

The Waipio system of cutting lines, described in the annual report for 1922 of the Irrigation and Fertilization Committee of the Hawaiian Sugar Planters' Association, is about 18 acres in extent at Waipio. A year's trial shows that it is not adapted for the level areas, requiring much more water. The advantage gained is in the doing away with the washing on the palis. Heavy paper about 2 feet square in size is placed on the bottom of the cuts. This keeps the cuts at an even level.

DITCHES

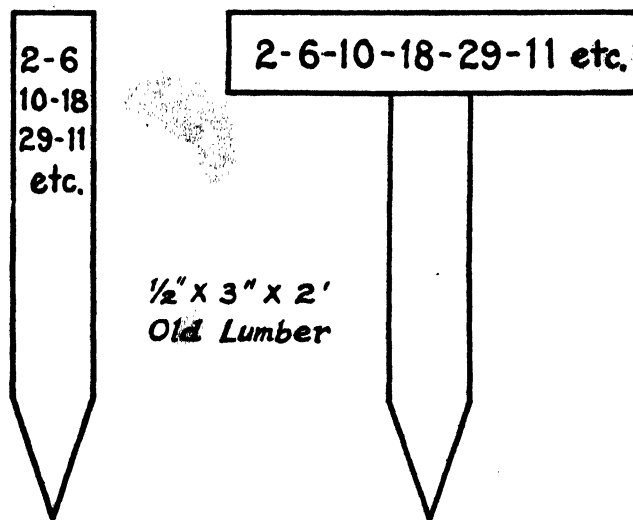
Several large ditch projects were underway this year. Kilauea completed a ditch bringing some 10 million gallons a day from the Kalihiwai side. It required a large amount of tunneling and a long syphon, all work being done by the plantation. Lihue started a huge project of tunneling the mountains to Hanalei, that this water may supply more water to Lihue and Koloa. Paia and Puunene are still doing considerable big ditch work. Koloa completed a long ditch of two miles with concrete lining that will save a large seepage loss. Pioneer is improving its ditches by concrete lining. Oahu Sugar Company is using blue lava stone slabs 1'x1'x4" for lining ditches filling the cracks with cement, and putting in a 3 to 4-inch concrete bottom. This type ditch can be constructed for a little over \$2 a foot for a 3½ foot wide ditch, where rock is available. Objections have been raised that water leaks through the cracks between the stones and gets behind the wall. But with this type, individual blocks can be taken out when cracked and the ditch quickly repaired.

As to field level ditches, the tendency in the Islands at the present time is to put the ditches closer together. Manager Thomson of Oahu Sugar Company reports that 40 to 45 lines of cane is the optimum distance between ditches. The ditches are being shortened too, meaning more straight ditches, of course.

Ewa has field tests installed with 20, 30, 40 to 60 lines per level ditch which will give them valuable data.

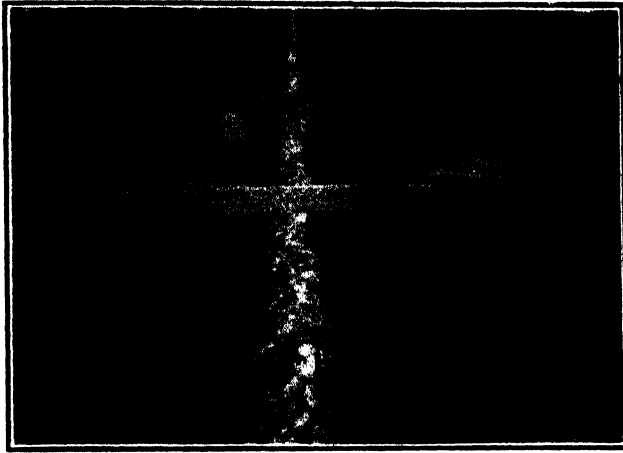
METHOD OF MARKING IRRIGATION

Many of the plantations use a "lepo" or earth pani at the head of the level ditch to mark the day of the irrigation. The use of a stake for this purpose instead, is not new in application, but is a practical means of getting closer supervision. It is the writer's opinion that the poor stand in many H 109 fields using body seed, is due to a failure of the water lunas to properly get their second and third waters on time. One plantation on this island figures that the second water can be delayed as much as ten days, with good results, but the writer advocates prompt attention and observations for the first irrigations to insure a good stand. The amount of water need not be great, but the seed must not dry out. Koloa this year uses a stake at each level ditch especially in the plant field, marked thus:



The ditchman has a blue lumber crayon and marks the date of the irrigation each time the ditch is completed (or started). Thus an exact record is had of the irrigation for at least 10 irrigations instead of one or two soil markers. The overseers and manager riding around, on seeing some dry or yellow ditch can tell right away the history of the field as far as water is concerned and there is thus no trusting to memory or scratch pads for the water, for days come around faster than one imagines on irrigation work.

Hawi has a number on each level ditch gate as:



A report of each operation for the level ditch is made by the water or section luna, and kept in his note book and a copy sent to the office. Days of month in one column, number of level ditch in other, with symbols as "I" for irrigation, "H" for hoeing, "F" for fertilizing, etc. Possibly other places have other ways of keeping tab on the irrigation, but no matter how it is done, the essential is to give the plant cane a good stand. Replanting is an expensive item.

TRASH PANIS

Koloa now uses the "Maui" style of trash pani, introduced on Kauai by Manager Caleb Burns. On the palis especially, instead of a flimsy small trash pani that washes out on second water, this pani is in "for keeps". Many plantations could improve on the type of pani used. It costs but little more to put a good one in like the Maui pani, and it is cheaper, for it stays.

WATER MEASUREMENT

The Sugar Planters' Experiment Station is making a detailed study of measuring devices. One will note in travelling to the various plantations, the increased use of weirs for measuring water. The rectangular weir is more commonly used. At Ewa, Hawi and several other plantations, the Gurley self-recording meter is in use, giving an exact record of the flow. A type of less expensive meter of the orifice type when recently tested out, checked out within a very close amount of a weir measurement. This records in acre feet. Shortly the Station will be able to say under what condition it may be used to advantage, but further testing is in order. The value of the cheaper instruments lies in our knowing the exact amount of water entering each field, and not figuring by our pumps, for seepage losses vary also.

Waimanalo is measuring water going on to many of the fields. With the new method of *growth measurement*, valuable records of what are happening to our fields may be recorded, and a correlation made between the amount of water, soil temperature, growth, fertilizer action, etc.

CONCRETE GATES

• Many plantations have put in concrete gates on straight and level ditches. Head Luna Eby of McBryde has applied for a patent on a portable concrete gate. The essential features are a reinforcing with pig-wire netting, a two-inch thickness of the slab, light and portable, and an iron slide door. The use of lumber for water gates runs into huge sums on the bigger plantations, and these inexpensive concrete gates will not burn out from cane fires. The objection raised is that they may chip. They are easily replaced. The cost is estimated at \$2.50 apiece without the iron door.

W. P. ALEXANDER'S BULLETIN

One of the biggest additions to the irrigation work in Hawaii for the year is W. P. Alexander's Bulletin on "Irrigation of Sugar Cane in Hawaii," wherein is recorded for reference all the irrigation data published up to this year.

IRRIGATION OBSERVATIONS

The writer has observed during the year the following tendencies:

(1) Shorter level ditches, and fewer lines of cane in a level ditch, where water is a problem. Say an optimum of 40 to 45 lines of 5 feet in width.

(2) Where there is a water shortage, the old style of "one-line-one-line" is considered the best method.

(3) Lines are shorter. 30 to 35-foot water courses more in vogue.

(4) The importance of getting water on the ratoons immediately, especially with H 109 cane, to insure a good stand on the ratoon.

(5) A tendency on many places to leave wide watercourse pathways, that is, not heading out the lines properly. The new Moler-Oleson planting machine will insure well-headed-out lines. Some plantations always place two seeds at the water course, and this we believe a good practice.

(6) More and more electric pumps are being installed, large and small.

(7) The semi-diesel engines are increasing in numbers, giving very cheap water with present low prices of oil.

(8) A desire on the part of some plantations to record the water going to the fields. The orifice type of instrument mentioned previously will supply a need.

To mention irrigation for the year without mentioning drainage would be a mistake.

DRAINAGE

Drainage is equally as important as irrigation, and is linked with it. The Islands have always had an open drain system, but the use of tile drainage is a new thing to us, although it is not to the mainland, where thousands of acres have been reclaimed, salt lands being made arable.

R. A. Hart, of the Bureau of Public Roads, U. S. Department of Agriculture, came to the Islands this year to study the drainage of the following plantations: Laie, Koolau, Ewa, Makee, Koloā, Olāa and Kekaha. The plantations bore Mr. Hart's traveling expenses on a pro rata basis. He spent two months in the territory and his report will be available during the coming year.

The importance of this subject is best answered by the letter sent in by Manager George F. Renton, Jr., of Ewa which follows:

Ewa Plantation Company has been operating a tile drainage system since May of this year. The tiles are buried in a field of 58 acres, according to an experimental scheme worked out by Mr. Hart, Senior Drainage Engineer of the U. S. Department of Agriculture. The questions which it is hoped to answer are:

- (1) Is the draining of sugar cane land by means of tile practical and profitable?
- (2) Will increased yields of cane result from a lowering of the ground water table?
- (3) Will it be easier to ripen the cane and increase the sugar content?
- (4) Will the accumulated salt be leached out?
- (5) Will the cane require less water on account of an increased root growth?
- (6) In installing a tile drainage system for sugar cane under Ewa conditions:
 - (a) At what distance should the laterals be placed?
 - (b) At what depth should the tile be buried?
 - (c) What size should the tiles be?
- (7) Do our fertilizers—nitrogen, potash and phosphoric acid,—leach out of the soil or are they fixed immediately?

The experimental data to be secured by the plantation is large and involves:

- (a) Measurement of the water applied to the field and the amount of water discharged at the outlet of the drains.
- (b) Soundings of the ground water in almost 100 observation wells located at necessary points in the field.
- (c) Analysis of the drainage water and ground water.

The field in question should in time show the value of the drainage work for Ewa. Tile drains to the extent of some 12,000 feet of 8-inch and 4-inch tile were laid, and as Manager Renton says above, complete records are being kept that they may know if the installation was worth while.

Waipio had a spot of about one acre which never yielded any cane, the cane drying out completely in parts. Several open drains were cut, the water table lowered from 1½ feet to 2½ feet or 3 feet, and now heavier yields are obtained than in any other part of the field.

Kekaha has a 500-acre swamp. Manager Faye has an extensive project started in draining this gradually, and pumping the water from the swamp by a Semi-Diesel engine to a higher sandy area adjoining new land.

Some of the advantages of drainage are:

- (1) Removing harmful salts.
- (2) Lowering water table. Making a more uniform water table for a fluctuating one is bad.
- (3) Excess water removed.
- (4) Better aeration of soil.
- (5) Soil temperature raised.
- (6) Deeper root area.
- (7) Better quality of juices expected.

The Straining of Raw Juice*

BY S. S. PECK AND E. W. GREENE †

The present practice of straining raw mill juice consists in passing it through perforated metal strainers which catch the larger broken cane particles, removing them by scrapers and carrying them back to the mill. The object of this straining is to remove such particles as will interfere with the work of the pumps and distributing systems of maceration. The size of screen opening varies widely in different factories. It is generally stated in number of openings per square inch, and ranges from 72 to 225. These are controlled by the width and length of the strainer, the rate of travel of the scrapers, the variety of cane ground, the condition of the returner bars and grooves, and the quality of the preparation of the cane and milling. The system makes no pretense of removing all the suspended matter, which amounts to from 0.3 to 0.7% dry matter on juice. This consists of broken cane fiber, fine trash fiber, and the dirt and soil brought to the mill on the cane. The presence of some of the cane particles has been found necessary to insure a press cake that will filter well and wash rapidly. In fact, instances are known where the size of the openings was increased because of this reason alone.

In several reports of this Association and of the Hawaiian Sugar Planters' Association, the views of several writers have been quoted stating the desirability of replacing this part of the milling equipment with something better, not only because of the mechanical difficulties arising from broken chains, broken screens, etc., but principally because this station is a breeding place of infection and fermentation of the adhering cane particles, whence contamination of the whole juice is aggravated. Steaming the upper surface of the screen, chains, and slats reduces this danger considerably, but the lower surface of the screen is not reached and presents a large and growing bacterial population to the juices passing through. It is difficult, almost impossible, to keep clean, but is a necessary evil in the milling equipment.

With a view to removing further amounts of suspended matter, finer perforated screens have been tried on the mill strainer, up to 625 openings per square inch. Trouble usually followed due to particles of cush-cush being forced by the rubbing action of the scrapers into the openings and eventually reducing the straining area. This could possibly be corrected by using woven-wire screens with the same size opening and presenting a much greater straining area, but these are impracticable where the accumulated material has to be removed by such a means as the scrapers. Trouble also developed at the filter-presses which reflected the absence of the filter-aid of the fiber particles in size between the 625 screen and the larger mesh.

*Presented at the second annual meeting of the Hawaiian Sugar Technologists, Honolulu, October 22, 1923.

† Sub-Committee on Juice Straining and Juice Strainer, Association of Hawaiian Sugar Technologists.

During the past two years the attention of sugar house operators has been occupied with studies of methods of improving our raw sugars for refining purposes. After the report read last year on this subject, it was decided to concentrate attention on the study of the causes of and possible remedies for the difficult filtration of our sugars as contrasted with foreign products. This has been very thoroughly investigated by the Station and forms a part of a report to this meeting by W. E. Smith.

Among the remedies suggested at the last meeting was the fine straining of the raw juice; that is, it would appear that if this juice were freed of the greater bulk of its suspended solids before liming and heating, it would give a clearer clarified juice and also a cleaner sugar. The theory was, that in boiling this material in sugar liquors in the presence of lime, there was either a solution of certain components of the cane fiber or a hydrolysis of some of the constituents into soluble compounds. Several laboratory tests have shown that boiling juice in the presence and absence of matter which can be removed by straining through a fine mesh screen shows decided differences; without straining the resulting clarified juice had a lower purity and contained a larger percentage of solubles precipitable by alcohol than was the case with the strained juice. Later investigations have shown that such dissolved impurities do not play a very important role in making for poor filtering sugars, although they contribute to it. But it has also been found that fine straining before liming and heating does improve the filtrability of the resulting syrup, due to a reason which will be brought out in Mr. Smith's report on this subject. One experiment gave the following results:

	Unstrained	Strained
Purity	86.7	87.7
Filtration Rate of Syrup	40.0	49.0

STRAINERS

Four types of strainers have been brought to your attention, three of which have originated in Hawaii. The *Carter Defecated Juice Strainer* was intended originally for the treatment of clarified juice, as the name indicates, and was later tried on raw juice.

It consists of three inverted conical screens, one above the other, mounted on a vertical, rotating shaft, the whole enclosed in a steel plate housing. This apparatus was installed at Waipahu early in 1923 for trial in screening raw juice after it passed the regular mill strainers.

The Carter strainer did not operate successfully under these conditions and it was removed from the Waipahu Mill.

An inclined juice screen operating by gravity and without moving parts has been in use during all of the 1923 crop at the mill of the Oahu Sugar Company, Waipahu. The screen frame is set at such an angle that when raw juice is distributed at the top of the incline it will pass through readily at the same time washing the separated suspended solids gently toward the lower end of the screen where they discharge.

During this year the fineness of screening was limited by certain features of the mud station. However, with 50-mesh screen there was a separation of

70 to 75% of the suspended solids. The cusp-cusp was discharged in satisfactory condition without excessive dilution.

Changes are now being made in the mud station and it is anticipated that next year either 80 or 100 mesh screen can be used.

At Kahuku a revolving juice strainer has been in operation all season. During the early part of the crop only half the juice was strained, so as to allow some bagacillo for the presses. Since July 5th all the juice was strained. This strainer was also put in at the factory of the H. C. & S. Co.

CAPACITY

At Puunene all the juice from the crushers, first and second mills of the two tandems was taken care of by a six-foot strainer. This amounted to about 19,000 gallons of juice per hour. The machine was a little crowded; it would be safe to say that the capacity is 16,000 gallons per hour.

MATERIAL REMOVED

In an installation at Los Mochis, 75% of the suspended solids was removed by a strainer covered with an 80-mesh screen, the suspended solids dropping from 0.4% to 0.1% of juice. At Puunene it amounts to a similar quantity, being about 0.3% of the cane. On a crop of 200,000 tons of cane this would be equivalent to 1000 tons of bagasse of 42% moisture, or a direct fuel saving to that extent.

NATURE OF BAGACILLO REMOVED

Because of the straining action of the bagacillo itself, much material smaller than the screen openings is taken out of the juice. In one test at Kahuku it was found that of the dry matter removed from the 100-mesh screen, 50% was smaller than this sized opening. It was an occasion of very dirty cane, and the bagacillo discharged from the strainer was chocolate colored.

QUALITY OF JUICES

The change due to the elimination of this matter on the quality of the juices was particularly noticeable at Puunene. The Dorr clarifiers had already made for a very much improved condition of the juices over previous years, but after the juice was fine strained a further very decided improvement resulted. The syrup from these juices was now clear and brilliant. It had a filtration rate at least 50% better than syrups from adjoining factories. A sugar made from this syrup, straight strike, and washed, gave a filtration rate of 116; the same unwashed was 109; and from a mixed strike 100.8. The turbidity of the sugar was 68 washed, 45 from the regular strike, and 28 from another factory doing usual work. At Kahuku since July 5th, and thereon to the end of the crop, all the juice was strained. There was an immediate improvement in the quality of the liquor, which was later shown in the sugars. They were able to carry a higher alkalinity than formerly, and had no trouble in the settling tanks as regards rate of sedimentation. There was a congestion here for another reason, which will be described later.

FILTER PRESSES

At Puunene under the Petree process there was naturally no filter press problem. At Kahuku, as soon as all the juice was sent through the strainer, there was an immediate response at the presses, the juice and mud spurting through the cloths, only a thin film of mud forming before the presses stopped running, and a sludge remaining which could not be sweetened-off. This was corrected by liming the settlings to distinct alkalinity, bringing to a boil, after which a perfect cake was formed, the rate of filtration was better than ever before, and the cake could be sweetened-off to 2% polarization in the usual time of washing. On emptying the presses they were found with a full cake at each frame, up to $1\frac{3}{4}$ inches thick, with only about 62% moisture, and so dry that they fell off the cloths readily, leaving clean cloths. Instead of being crowded with five presses, it was found possible at times to do the work with three.

In liming the settlings to this alkalinity, it was not thought good practice to mix the press juice with the clarified juice to the evaporators, so the press juice was sent back to the raw juice. This additional juice along with the washings crowded the settling tanks, which were rectangular tanks, 4 feet high, with the lowest draw-off one foot from the bottom. The difficulty was overcome by emptying the settlings after every second fill; that is, the draw off to the presses amounted to one-seventh of the volume of juice instead of one-fourth as was the case formerly. There was no further trouble; the second settling took place as rapidly as the first. The juices were clean at all times, and the presses were easily capable of handling all the work.

Criticism might be offered toward this practice of high liming the settlings, with the possible effect on glucose and darkening of the juices. No such condition was observed. It is very possible that the time of heating and contact with the high alkaline solution is not of sufficient duration to make for any decided reaction in this respect.

The effectiveness of the straining was shown at Kahuku in two products. The clarified juice was as usual run over a 100-mesh screen, but there was no longer any need for it, as practically nothing was collected thereon. A sample of cake was washed through a 100-mesh screen, and left only 0.28% dry residue, whereas the ordinary cake showed up to 20%.

A report from Kahuku to the committee on boiling house methods shows the quality of the work obtained there as regards waste molasses for the 1923 crop. There were possibly several contributing factors to this excellent showing, but it is thought that the remarkably free character of the low grade products was primarily due to the effect of the strainer.

A further interesting development in milling practice is the invention by the Honolulu Iron Works of a pump which will handle unstrained juice with all its accompanying coarse cane particles. From this will be possible the practice of returning juices intended for maceration without straining, relieving the equipment of this part of the mill strainer and correcting the objectionable practice of saturating partly exhausted bagacillo with the richer juices from the first mills. It is further suggested that the mixed juices be elevated by the same kind of pump through a fine-mesh screen so that the straining can be done in one

operation and the present type of mill juice strainer be entirely discarded. The separated material can be brought back to the mill by a scroll conveyor; or where conditions permit, the strainer can be placed directly over the mill at a place where the removed bagacillo will drop directly onto the bagasse blanket.

Report of the Committee on Petree Process*

BY S. S. PECK †

As the result of one season's operating with the Petree Process at the factories of the Hawaiian Commercial and Sugar Company and Maui Agricultural Company, the experience of those operating will be of unquestioned value to the members of this Association.

As a matter of particular interest, we include as a part of this report a letter from Mr. E. E. Hartmann, an old time resident and chemist of Hawaii, now connected with Petree & Dorr Engineers, Inc. As stated by him, his calculations are based on figures supplied him from the factory records, all of which have been derived in the usual manner, with some modifications added to take care of the conditions which differ from the usual mill practice.

One question which is usually asked is: "What is the effect on the mill rollers?" At Puunene there was no question but that the return of the hot mud affected the roller surfaces very adversely. It appeared that the polishing action was not so much due to the mud itself as to the absence of the natural acidity of the juices in the blankets, whereby the roller surface was not continually being roughened by the etching action of the liquors in the bagasse. This was evidenced by the fact that the rollers lost practically no metal during the season. But, particularly in the case of the top roll in the fourth mill, where it might have been expected that this action would be the least effective, it was necessary to regroove very frequently. All the top rolls are grooved eight to the inch. As a consequence of the polishing, there were frequent chokes at the mills with corresponding delays. This condition was partly corrected by (1) using old maceration water. The colder the bagasse blanket the better it seemed to feed. (2) By cooling the settlings returned to the mill. In both these cases we explain the improvement by the lesser swelling of the fiber particles due to the high heat. (3) By fine straining of the juice before clarification. The evidence was particularly noticeable at the first mills, where that side of the rolls to which the returned cush-cush was directed lost its polish after a few days. It is also explained by the probability that in removing the fine absorbing cane particles, we were returning less material of alkaline nature to the mill and restoring to a large extent the acid reaction of the natural cane juice.

* Presented at the second annual meeting of the Association of Hawaiian Sugar Technologists, Honolulu, October, 1923.

† Sub-Chairman, Committee on Petree Process.

At Paia there was much less slippage at the mill, although it occurred to some extent. It is probable that this was due to either the Meinecke chutes, which allowed a slower and better penetration of the mud into the bagasse blanket, or to the coarser grooving of the top rolls, which was four to the inch. There was no strainer at Paia and hot mud was returned, but it was found advisable at times to use cold maceration water.

The next usual question is: "How about the extraction?" For the purpose of comparison, the figures for 1922 and 1923 are given:

	Puunene		Paia	
	1922	1923	1922	1923
Cane, Polarization	14.78	14.25	13.54	13.45
Cane, Fiber	12.53	11.95	11.83	11.76
Dilution % Normal Juice.....	36.09	38.11	25.57	47.95
Extraction	98.19	97.02	96.99	97.56
Extraction Ratio.....	.14	.25	.26	.21

It is to be noted that the differences between the two years should be a little greater because of error in calculation of bagasse weights due to the returned insolubles in mud.

We feel certain that the extraction at Puunene was low on account of the large volume of juice returned to process with the mud, thus preventing the proper circulation of return maceration in the usual manner. This amounted to about 30% of the cane. A calculation with definite assumed figures of fibres in bagasse and factors for admixture of maceration water substantiates this. During the 1924 season, with a better acquaintance of the conditions attending the process, it is expected that a return to 98 or better will be obtained.

At Paia better results for 1923 than obtained in 1922 as regards extraction were shown, but the dilution figures explain this. The 1923 extraction figures would have been still better had it not been for some trouble at the last mills in the driving gears which could not be corrected until between seasons.

Another question is: "Was the anticipated fuel saving realized?" There was a very decided saving at Puunene, so much so that at times up to 600 kilowatts were furnished for outside power from the mill power plant, and no oil was burned after the month of February. There were other conditions aside from the Petree Process which contributed to this economy. Some changes made in the boiler installation were largely responsible, and molasses was burned under the low pressure boilers. It is therefore difficult to estimate how much of the reduction in the fuel bill is due to the process, but it is certain that from the less loss in radiation, the elimination of the filter-press station, and the extra fuel from the returned mud, this was no small figure.

At Paia, other conditions existed. The irregular grinding and the poor work at the last mill, leaving a high moisture in bagasse alone, explain the demand for extra fuel which was greater than in 1922, but less than in 1921. The difference in results in the two factories makes any positive statement in this connection quite impossible.

RECOVERY

. In both factories there was a higher recovery reported than in previous years. In attempting this comparison, it must be remembered that there is no mixed juice figure on which to base a strict comparison. We have made a calculation for Puunene, starting with the crusher juice, which is a fairly reliable figure in this factory, and calculated a theoretical recovery from these purities, 100 extraction, the purity of the sugar as produced, and a 36 gravity purity molasses. This figure compared with the actual recovery takes into account any improvement due to clarification. A comparison of three years follows:

Recovery % Polarization in Cane	1921	1922	1923
Theoretical Recovery	93.93	93.90	94.42
Actual Recovery	89.61	88.57	90.77
Efficiency	95.40	94.32	96.13

It is to be noted that in 1921 the cane was ground in a 15-roller mill. The figures reflect approximately the savings due to no filter-press losses, to less under-terminated losses, to a better rise in purity during clarification (measured by the less drop in purity from crusher juice to syrup) and include also the greater loss in extraction in 1923. While not above criticism, we believe these figures demonstrate a real gain in sugar in bag over the previous years.

QUALITY OF PRODUCTS

The clarification of the juices, the resulting syrups, the commercial sugar, and the low grade work were all favorably affected. The juices and syrups were brilliant; the sugars cleaner than even with the juice filtration previously practiced; and the low grades worked so much better that only 60% of the low grade centrifugals were required throughout the crop.

LABOR ECONOMIES

There was no saving in labor costs in the milling department, but in the boiling house there were less men used because of the elimination of the filter press station and the running of a less number of low-grade centrifugals.

[Copy of letter to S. S. Peck* from E. E. Hartmann of Petree & Dorr Engineers, Inc., New York, N. Y.]

Having arrived in Honolulu after the two Petree process plants had shut down, I can, of course, only comment on the results.

The outstanding feature of these results is the 3% increase in boiling house recovery (2.93% sucrose in cane as compared with 1921, and 3.11% sucrose in cane as compared with 1922, based on the theoretical recovery of 1923).

There has been a loss in mill extraction, amounting to 1.45% sucrose in cane as compared with 1922. 1921 cannot well be compared with the last two years, as five mills were used in that year.

The net gain was 1.67% sucrose in cane or more than 800 tons of sugar.

* Sub-Chairman, Committee on Petree Process, Association of Hawaiian Sugar Technologists.

We have every reason to look forward to a much better total recovery next year, as steps are now being taken to remedy the conditions, which led to the falling off in extraction.

A good deal of mud was circulated (Mr. Peck found the settlings to amount to as much as 30% of the cane). It looks to me as if the Ramsay macerator were not a suitable distributor for the mud. The impression I have received from descriptions of this operation, is, that where the macerating mud strikes the surface of the rather compact blanket of bagasse, the clear liquid is absorbed, the mud forming a cake on the surface, clogging it against access of more macerating mud. As a result a portion of this mud seems to have been carried in pockets to the third mill, there to be re-expressed.

The absorption of this mud in the bagasse is clearly a function of the surface of the latter. At Puunene this surface area was very restricted. One way of remedying this condition would be to break the blanket of bagasse and to apply the macerating mud from the top at the point where the blanket is broken, thus increasing the surface area of the bagasse.

A radical change in procedure, such as is introduced by the Petree process, is sure to cause temporary disturbances in the factory and it also may affect methods of control. This fact has naturally given rise to a number of objections and criticisms, which I shall here discuss and answer as far as they have come to my notice.

In calculating the mill extraction, it is necessary to take cognizance of the fact that the insoluble matter returned to the bagasse carries off as much, or practically as much, sugar as the insoluble matter in the bagasse. In this instance we find the bagasse % cane originally reported as 21.68%. To this we have to add the bagasse equivalent of $1.02 - .07 = .95\%$ insoluble matter in mud, or $.95 : .55 = 1.73\%$ cane. The sucrose % bagasse should therefore be multiplied by 21.68 plus 1.73 = 23.41 instead of only 21.68, and the loss in bagasse % cane is then correctly given as .457 instead of .42.

A question, which the introduction of the Petree process has brought up is: "To what extent does this change in procedure affect the sucrose value % cane?"

A slight correction should be made for both the Petree and the filter press methods of working, as shown below.

Where filter presses are used the figure for bagasse % cane was slightly too high, because the fiber in the bagasse is compared with the total fiber in cane and not, as it theoretically should be, with only that portion of the fiber which goes into the bagasse.

A similar small correction should be made where the clarified juice is weighed, as in this case the fiber in the bagasse should be augmented by that portion of insoluble matter, which was not originally in the juice.

These two small errors are cumulative in comparisons, as they tend to make the figure for sucrose % cane slightly too high where the mixed juice is weighed and slightly too low where the clarified juice is weighed.

The insoluble portion of the material entering the mill appearing on factory reports as "gross fiber in cane" has only one outlet in the Petree process and that is in the bagasse. Where filter presses are used, a portion of this insoluble matter finds its way into the presscake.

In the Petree process the ratio: insoluble in bagasse to insoluble in cane gives a value for bagasse % cane, which for complete accuracy would have to be increased by the percentage of solids precipitated from solution in the juice together with the lime contained in the precipitate. The organic matter precipitated from the juice can, if in the absence of data on the formation of volatile products we may ignore this factor, be approximately measured by the increase in purity of the juice during clarification. This increase has been about 1 in 1921 and 1.1 in 1922. This increase is equivalent to the elimination of .15% cane of solids of the specific gravity of sugar.

If the press cake amounts to 2.5% of the cane and contains 8% of lime, the lime in the precipitate would amount to .20% cane and the total precipitate to .35% cane.

If this precipitate carries off as much juice as the bagasse, the bagasse equivalent would be $.35 : .55 = .64\%$ cane.

The bagasse % cane is originally reported as 21.68, the increase due to the addition of this precipitate is therefore $.64 : .2168 = 3.0\%$ and the sucrose in bagasse % cane is increased by 3% of .42 or .013 making the true loss .433 instead of .42%, and the percentage of sucrose in the cane 14.263 instead of 14.25.

Where filter presses are operated, the ratio: insoluble in bagasse to insoluble in cane gives too high a figure for bagasse % cane, as pointed out above. The correction applied to the 1922 figures was arrived at in the following manner:

Sucrose in bagasse % cane as reported.....	.27
Sucrose in juice % cane as reported.....	14.51
Insoluble in press cake cane as reported.....	1.02
Precipitate from clear juice % cane.....	.35

Insoluble originally in juice cane.....	.67
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$.67 : .55 = 1.2$ bagasse equivalent % cane.

$1.2 \times 100 : 21.75 = 5.5$. 5.5% of .27 = .015.

True sucrose in bagasse % cane = $.27 - .015 = .255$ instead of .27.

True sucrose in cane = 14.765 instead of 14.78%.

These corrections are small, still they should be applied when making comparisons.

The introduction of the Petree process has given rise to the question, "Does the substitution of the clarified juice for the mixed juice as a basis for the calculation of the sucrose in the cane affect the latter figure, in other words, is it not possible that a loss of sugar occurs in the process of clarification?"

We know that inversion cannot take place in a sufficiently limed juice. Just at what point of alkalinity a juice may be said to be sufficiently limed has so far been purely a matter of opinion. Experiments recently carried out at the H. S. P. A. Experiment Station indicate that there is no inversion in a comparatively heavily limed juice, while on the other hand, inversion does take place in juices held at a temperature of 212° F. for a number of hours, even if slightly alkaline. The exact danger point has not yet been established, and it is conceivable that this point may be a different one for different varieties of cane.

That no measurable loss had been sustained in clarification at Puunene is evidenced by the Java ratio which was 82.15, 82.39, and 82.37 for 1921, 1922, and 1923 respectively.

The above leads to the conclusion that the sucrose weights obtained from the mixed and from the clarified juice are strictly comparable where juices are properly limed.

The question has been put to me: "Granted that a much higher recovery has been coincident with the operation of the Petree process, is this due to the Dorr clarifiers or to the double clarification, or to the elimination of the filter presses, or to the well known fact that more attention is paid all around when any important change is made?"

I have no doubt every one of these factors helps in bringing about the improvement in recovery. Just what share each of these factors contributes, I don't know.

In regard to the first item I would report, that while the Dorr clarifier admittedly gives better clarification than any other clarification system and consequently a better product, the earlier successes of the Petree process were obtained without it.

It is reasonable to expect that double clarification of the more impure fractions of the cane juice will secure a more complete elimination of the impurities, particularly of those, which are in a very finely divided or even colloidal state. The juice which undergoes double clarification consists of the fractions extracted by the second and subsequent mills, the juice contained in the mud of the primary clarifier, which latter should never amount to more than 10% of the weight of the cane—at Soledad it amounted to from 5 to 8%, and the clear juice from the secondary clarifier.

That there is an agglomeration of particles in the secondary clarifier different from the ordinary mud, can be clearly seen when comparing the mud discharge from the primary and secondary clarifiers. Whereas the former has a thick and slimy appearance, the latter consists of a freely running mixture of juice of low viscosity with a granular mud.

At Soledad this difference was very striking and yet the percentage of insoluble matter in the heavy primary mud and that in the fluid secondary mud was approximately the same, varying between 8 and 10%.

That a large portion of these substances, gums, waxes, and possibly starches, which are present in the juices in a condition so nearly akin to solution that the juice containing them may appear quite clear to the eye, are eliminated by this procedure, is evidenced by the better boiling quality of the intermediate products, and by the better quality of the sugar.

Now we come to the filter presses. That there are losses sustained in their operation, which do not appear in the figure for loss of sucrose in press cake, will be generally admitted. The item, undetermined losses, covers as we all know, a multitude of sins, but there does seem to be a tendency for these losses to be highest when the loss of sucrose in press cake is lowest. Is it not probable that an appreciable amount of deleterious impurities are redissolved from the press cake while washing?

There are other drawbacks to the operation of filter presses. In the best regulated filter press station, defective cloths will be found, and consequently a faucet here and there will discharge muddy juice; cloths may sometimes not be properly put on and a press may leak on the side. There are so many chances for some of the very fine mud, which we know impairs the boiling house work, to find its way back into the clarified juice.

The last factor mentioned, the psychological one, contributes its share unquestionably to better efficiency. It is so intangible however, that whatever benefit it brings may well be credited to the change which introduced it.

I should like to refer to one more suggestion which has been made, and that is, that the quality ratio be used for comparing one year with another.

The quality ratio is based on a constant for loss in press cake and undetermined, and on another constant for the difference between the crusher juice and syrup purity.

As it is just in these items that the Petree process shows the greatest improvement over the older methods, the use of the quality ratio as a basis of comparison between the two methods of working, is out of the question.

If the combined action of all the factors above enumerated brings about such a decided improvement in boiling house recovery and general working conditions in addition to the direct savings in labor and supplies and a product of better quality, are we not justified in judging the process by its results, leaving the analysis of the various phases and the apportionment of the credit properly belonging to each, to the time when sufficient data will be available to do so?

The fact remains that the Petree process has saved the owners of the factory three dollars on every ton of sugar, and there is every reason for expecting better results next year.

I leave Honolulu feeling confident that the process will have the benefit of the same searching and fair scrutiny next season as it had the past year.

Report of the Improvement of Cane by Selection*

BY F. A. PARIS

I do not feel like presenting to you today any results obtained up to now by bud selection work as I decidedly believe that it is too early. It would only lead to endless discussion of no practical importance and our meeting would come to an end without bearing fruit.

Environment, natural and artificial, causes such enormous fluctuations that only after many years of accurate testing of individuals and progenies, will any light be thrown onto the problem of bud selection. Besides that, certain defects in our methods are likely to lead to wrong ideas and premature statements. I shall come back to that subject in a later part of my report.

* Presented at the second annual meeting of the Association of Hawaiian Sugar Technologists, Honolulu, October 22, 1923.

I divide selection work into two distinct fields of action, one of which is based on facts of immediate profitable influence on our industry, now and in the future:

1. Plantation selection or mass selection of seed. The other of a more experimental nature which may or may not be immediately productive.
2. Bud selection.

PLANTATION SELECTION

Let us briefly pass in review a few of the valuable points of mass selection. In any branch of agriculture its importance is recognized, anyone who has been farming in a temperate climate or knows anything about it, will agree with me. Years ago anything was good enough for seed, the cheapest was the best. The smallest potatoes, and even cut into small pieces, were picked out for planting, later on that method proved wrong and the best seed, and the most profitable, is a well-formed tuber of average size, with good eyes. The same opinion, that the best only is good for seed, rules for any other crop, and special machines have been invented for grading and special areas set apart for the production of superior seed.

In animal breeding too, great results have been obtained by careful, continual selection of the breeding stock. The importance of mass selection of seed in sugar cane is beginning to be noted, and is becoming a practice. I have not failed to be told whenever I saw a thin, weak stand of plant cane that the seed was poor, and the contrary whenever a new field made a good impression.

Mass selection of seed is a time and money-saving device on a plantation, as everywhere success depends upon a quick germination, a strong start of the vegetation and a good stand. In time it will be absolutely indispensable for the purpose of maintaining the pure strains that bud selection may isolate.

Once more I make the statement that mass selection of seed is indispensable for the success of our industry.

How could we systematize mass selection and introduce it as a plantation routine?

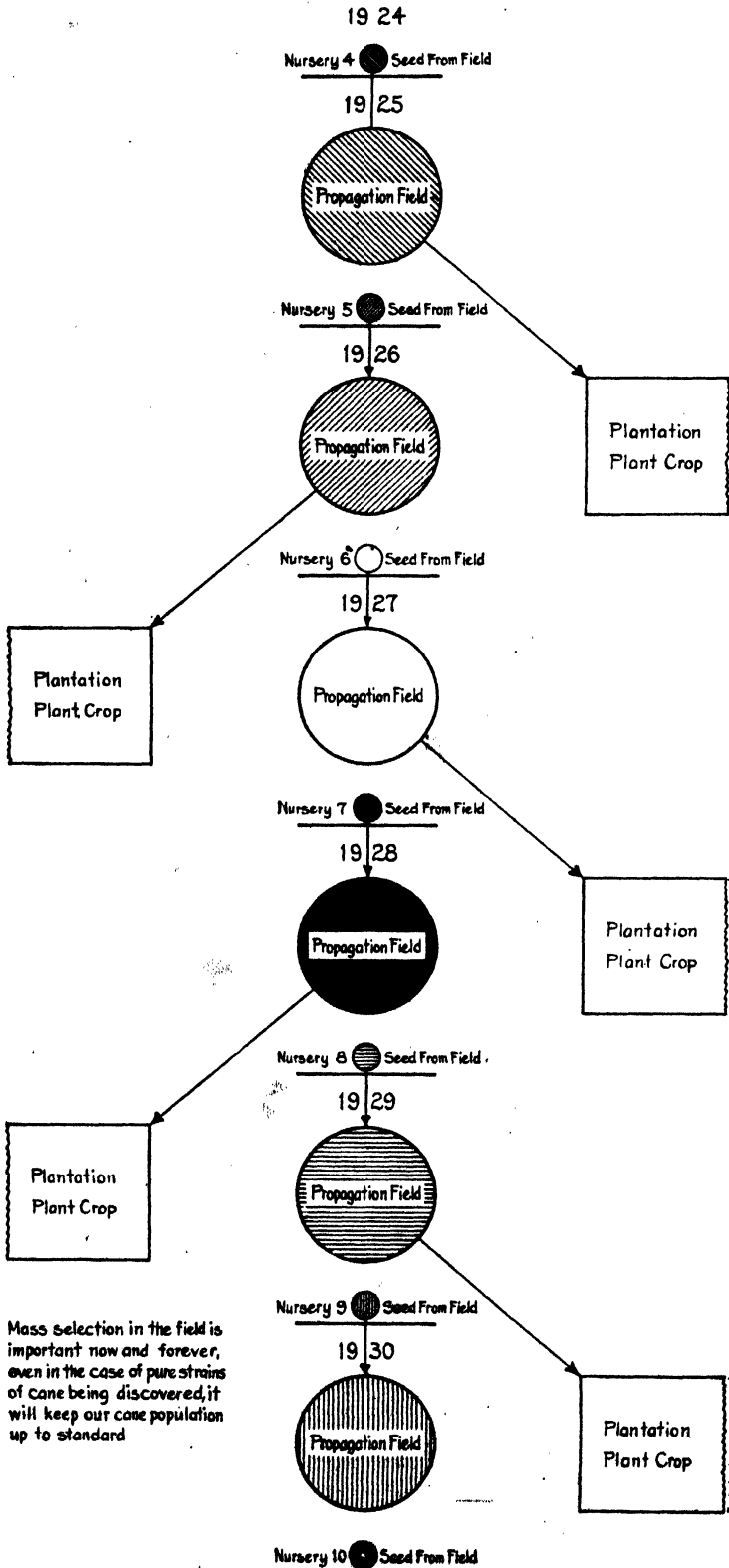
By instructing our seed cutters to leave out any weak or abnormal looking stalks, their eyes should be educated to recognize good and viable material. Besides the gang feeding the general planting we should organize a picked bunch of men under the supervision of a keen observer and collect with them the best seed there is, bag it in specially marked bags, the blue seed in blue bags, if I may express myself in that way. The picked seed should be planted in a separate section called field nursery, the same operation to be repeated every year. After one year in the field nursery the cane would be cut, reselected and the best planted in a so-called propagation field. From there, a year later, it would go as plantation seed.

The above method would lead to the establishment of an endless chain, an automatic grading of our cane population.

The following diagram will make clear to you, better than words, the layout of the scheme and its way of working from year to year:

MASS SELECTION SCHEME FOR PLANTATION SEED (LAYOUT)

PROPAGATION RATIO 1:5



We make a point of obtaining our seed for the field nursery from the field, conserving, by doing that, the valuable collaboration of natural selection. We shall get a better average type, the fittest of the fit.

As we go forward with the establishment of new field nurseries and propagation fields the ones low down on the list drop out. The acreage of the field nurseries should be in proportion to the area planted each year by the plantation. We adopted the ratio 1:5:5, meaning that a one-acre field nursery will plant five acres of the propagation field and that, in turn, five times more of plantation cane. If a plantation is planting an average of five hundred acres a year the propagation field should be one hundred acres and the field nursery twenty acres, that ratio would allow a careful selection of seed each time.

To complete the subject let us recapitulate a few more important items connected with seed for our field nurseries:

I presume that we all agree that top seed from mature cane is the best. In full grown cane the better individuals stand out more clearly, the eyes of such cane are larger and ready to germinate and the young shoots will find in the seed piece better nourishment; thus they will get a better start. I must mention here an exceptional case, under very bad conditions hard seed will probably give better results, it will deteriorate less rapidly than a juicy seed piece and we can practically say that the better the seed the more attention should be given in starting prompt germination. We also agree that seed from ratoon cane is superior to that from plant cane as we are more likely to find desirable individuals in cane having gone through a period of adaptation. Ratooning power is a vital point for the existence of many of our plantations. It is everywhere a great factor in minimizing the cost of production. In the establishment of our nurseries during the first two years we may have to make an exception and cut young plant, but we should go back to our rules as soon as conditions become normal. A good many more field operations have an influence on growth and should go hand in hand with mass selection but we cannot discuss them here.

BUD SELECTION

Taking into consideration the great part which environment plays in creating fluctuations, differences between individual plants, I do not think that it is possible to admit that we can pick out types straight away, among our cane population. It is only after a certain amount of individual study that we shall be able to recognize facial differences between our plants.

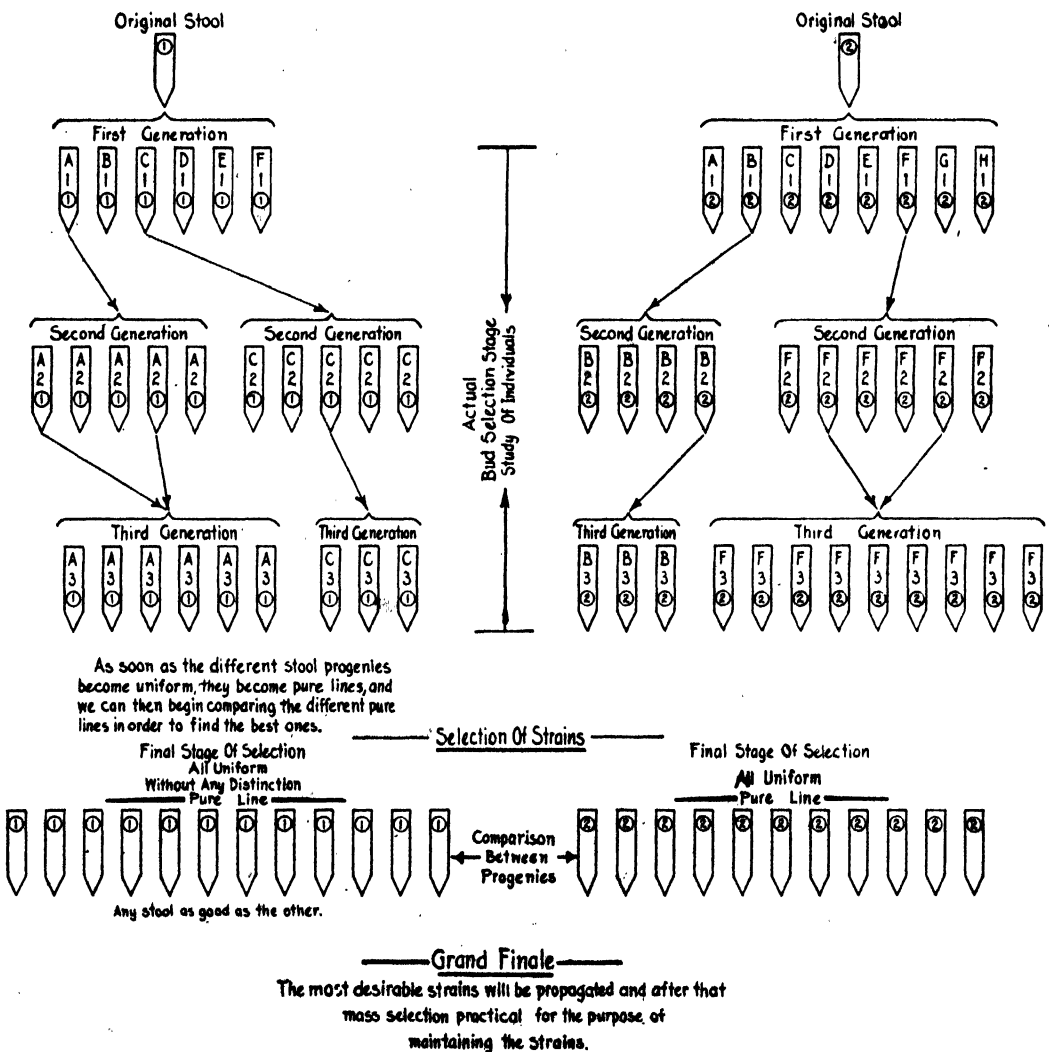
We should take as a unit first the actual bud until we are absolutely sure that we are dealing with pure strains. When that point is cleared up we can start a progeny selection or a type selection using the same methods we have already adopted. The present system has the disadvantage of going too fast. It makes any individual selection in the progenies impossible. You should not sail out of sight of the coast until you know how to take your bearings.

By carrying out, through several generations, a careful individual selection and an individual study of our cane plants we shall get to know the characteristics of the different types, making easier a later type selection suitable to our conditions.

The accurate knowledge we gain of the characteristics of types through individual selection and individual observation may be of great value for the improvement of our cultivation methods. With the present system we are trying to do two things at one time, mass selection or production of plantation seed, and bud selection. By dealing with a great amount of material accurate observation is impossible, and observation is the most important point in selection work.

I propose keeping back the present system for a while until we have isolated and studied the pure strains. It will not be a loss, as the plant material isolated up to now can be further investigated, and I advocate only a safer way of going forward into unknown territory.

BUD SELECTION AND STRAIN SELECTION SCHEME FOR STAKING



I suggest the following preliminary scheme:

Reserve a certain acreage in an accessible part of the plantation for the purpose of carrying out the first stage of our selection, individual selection in the progenies, where outstanding stools should be brought in, real queens which

would give the start to our progenies. These stools should be rooted out to make sure that they are from a single bud. It is essential before we start, to decide if we are looking for a type resistant to disease, or a high yielding type, etc., and collect our first material accordingly.

Personal disposition of the breeder has a great value as some of the valuable characters in plants or animals are hidden, they cannot be seen, so they must be felt.

An accurate record of the characteristics of the first stool must be taken, a photograph for general appearance and juice analysis would be useful besides other important details. The same system of weighing in use now would be kept.

Single-eye planting must be the rule until we reach uniformity among the individuals composing the progeny. Before cutting the stalks for seed, the best eyes should be picked out and the cane cut so that these eyes would be in the middle of a three internode seed piece. Each seed piece should have a node at each end for protection. The eyes should be planted three feet apart. Colors or names should make the distinction between progenies. Each eye in the first planting will get a letter which will be carried on from bud generation to bud generation to recognize the descendants from that eye. The generations will be recorded by numbers 1, 2, 3 and so on. The following sketch will explain the method of staking.

Once a definite proof is obtained of the uniformity of the material composing our progenies, we can calculate the average means for each and start our final selection, the type selection, on the same lines adopted now for the selection work started by Mr. Shamel.

Seedling work has a great importance beside bud selection and mass selection. Not only until we have found a few more cane varieties to suit our conditions, but also for the purpose of producing new varieties to take the place of our actual types of cane which may have lost the faculty of adaptation to an ever-changing environment.

Report on Soils and Fertilizers

BY W. T. McGEORGE

In preparing the report on soils and fertilizers an attempt has been made to cover, superficially, the activities and developments of the past year leading to a more complete understanding of our soil and fertilizer problems. Details are avoided, to eliminate duplication. On the other hand, a brief notation of all activities will add greatly to the future value of these reports and serve as an incentive for discussion at these meetings if details are desired. At present, practically all work of this nature has been performed at the Experiment Station, but it is to be hoped that in view of the broadening of the activities of the Technologists' Association, in the future wider attention will be given to this phase of the problems of our industry.

SOIL ANALYSIS

Soil samples are often submitted to the Experiment Station for analysis from which fertilizer recommendations are solicited. Mainland experiment stations are attempting to discourage such a practice, and rightly so, for the range of variation is too great in diversified agriculture. A definite association between chemical composition and fertility has thus far failed to materialize under such conditions.

Where we are concerned with only one crop our case is more specific. The value of soil analysis is therefore not beyond the range of possibility and in an industry such as ours, in which heavy fertilization plays an important role, the application of soil analysis would be of considerable value had we sufficient data on which to formulate a policy.

In the past it has been the practice of the Experiment Station to make interpretations from data based on analyses of samples representing comparatively few field experiments. Further analyses of Island soils of known history have added data, the value of which is strikingly apparent.

Phosphates. Since the data are being submitted in complete detail elsewhere only the results obtained with 1% citric acid, which proved to be most closely related to the results obtained by field experiments, are submitted here. A summary appears in the following table:

	Soils giving no response	Soils giving response
Average . . . . .	.0320	.0014
Maximum . . . . .	.3190	.0028
Minimum . . . . .	.0026	.0006

The above is an average of 39 composite soil samples from 22 field experiments located on the four major Islands. On the basis of the above and as a matter of policy, variations being admitted, the following suggestion has been offered. A plantation soil showing .0025% P_2O_5 or less, soluble in 1% citric acid will, with rare exceptions, respond to phosphate applications when planted to sugar cane. Soils within the range of .0025 to .0040% present a condition in which the availability is governed more or less by other factors and it would be the better policy to depend on field experiments in such cases. Finally, with rare exceptions, will soils showing greater than .004% P_2O_5 soluble in 1% citric acid respond to phosphate fertilization. ✓

Potash. Soil samples taken from 17 field experiments located on 13 different plantations on all four Islands were analysed by several methods and 1% citric acid was the only solvent which showed any promise. The results obtained by this method are summarised as follows:

	Soils giving response	Soils giving no response
Average . . . . .	.014	.054
Maximum . . . . .	.024	.082
Minimum . . . . .	.007	.031

On the basis of the above, the following policy has been suggested. A plantation soil showing less than .02% K_2O soluble in 1% citric acid will, with rare exceptions, respond to potash applications. Those soils within the range of .02 to .03% may be considered deficient in available K_2O and, depending on certain factors, will usually give a slight response while the soils above .03% K_2O will rarely give profitable returns from potash fertilization.

FACTORS INFLUENCING AVAILABILITY

While it is possible to definitely determine the solubility of any phosphate or potash compound in any solvent, a great number of factors which will limit the application of such solvent power to soils must be admitted. A consideration of some of these must be considered in interpreting soil analyses and limitations accordingly allowed.

Silica. A definite relation between the solubility of silica and availability of P_2O_5 as measured by 1% citric acid has been shown. A greater solubility of silica accompanies a greater availability of P_2O_5 and also a greater assimilation of P_2O_5 by the cane. Juices from cane grown on such soils are higher in P_2O_5 content. On the other hand there appears to be little or no relation between this factor and availability of potash.

Soil Acidity. The higher acidity of soils giving response to P_2O_5 is significant. The same is true of those soils responding to potash.

Lime. In general, the soils giving response to phosphate are lower in total lime, that present as carbonate, sulphate and easily soluble silicates and more especially that soluble in water saturated with carbon dioxide. We have also noted a greater assimilation of P_2O_5 on the high lime soils as shown by the higher P_2O_5 content of the juice. Again, in the soils from the potash experiments we have found considerably larger amounts of lime in those soils which field experiments show to be amply supplied with available potash.

Mechanical Composition and Availability. There appears to be little or no relation between the relative size of the soil particles and availability of phosphoric acid. On the other hand, the higher clay content of the soils giving no response to potash is significant. Also, color and organic matter appear to be related to availability of potash, being of higher availability in the red clay soils than the yellow type. Availability also appears to be lower in the highly organic soils. ✓

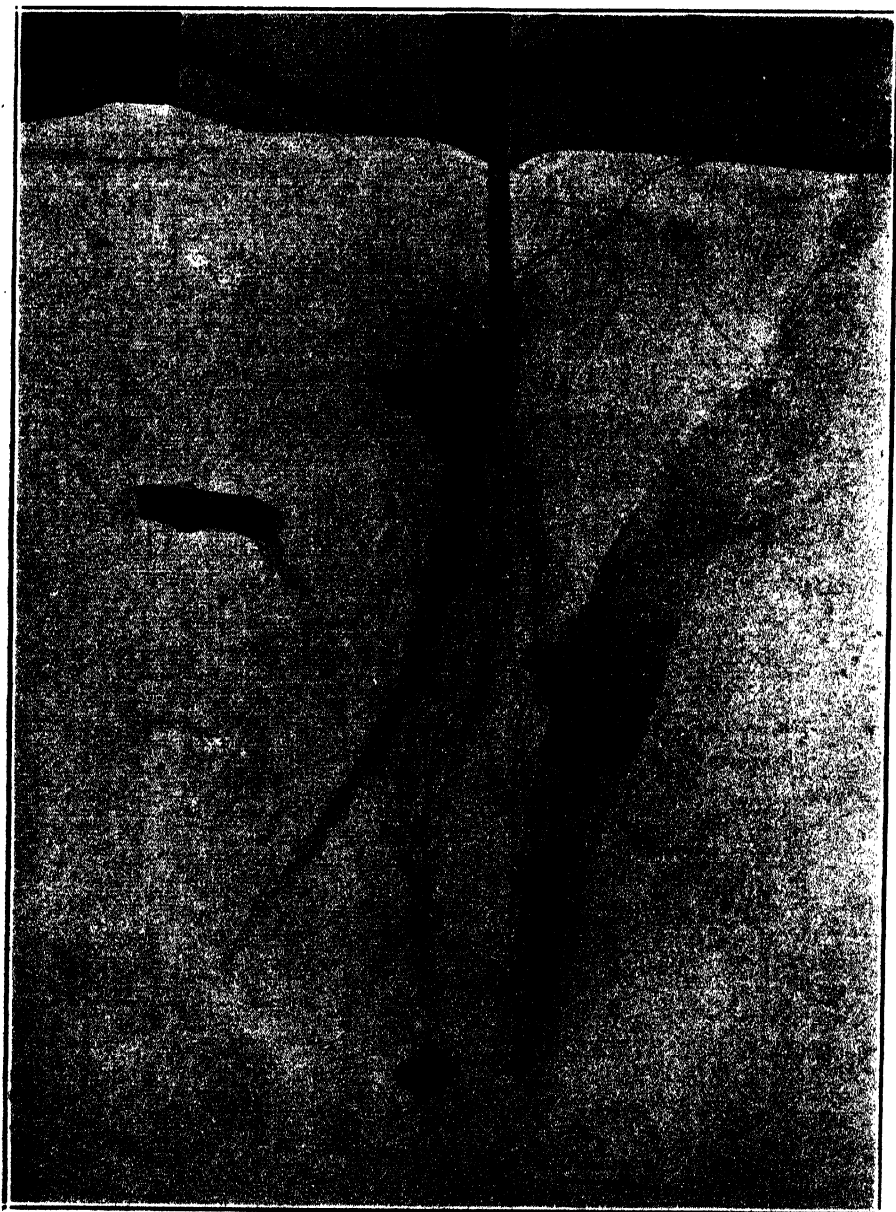
Hence, in making interpretations of the analyses of Island soils suggestions are not offered from the P_2O_5 or K_2O determination alone. Allowance is made for the influence of other factors and a knowledge or history of the past performance of the field or soil type. No "hard and fast" rule is possible and it is therefore essential that new field experiments be followed up with soil analyses, thus adding valuable data to that already accumulated.

NITRATES VERSUS AMMONIUM SALTS

The heavy nitrate applications are probably more directly involved in the heavy yields of cane on the Island sugar plantations than any one factor. Experimental evidence has shown that some crops will assimilate nitrogen as ammonia

and thrive normally in the complete absence of nitrates and nitrifying bacteria. As an illustration of local interest we may cite the rice plant. In view of the low nitrification in the acid Island soils the question arises: Is ammonia directly involved in the nitrogen nutrition of the cane?

Our experiments in water and sand cultures indicate practically no growth in the absence of nitrate. The buds may develop slightly if in contact with air but root development is almost completely lacking. The roots which do make a slight start are very dark in color and root hairs are almost entirely absent. The accompanying illustration shows the comparative growth of H 109 seed, grown for practically four months in sand cultures. These experiments clearly indicate the vital role which nitrates play in sugar cane nutrition.



Showing the root development in the presence of ammonium sulphate (left) and sodium nitrate (right).

TOLERANCE OF H 109 FOR SODIUM NITRATE AND AMMONIUM SULPHATE

When we attempt to apply the necessary fertilizer which is required to raise maximum cane crops under the most favorable conditions it is often asked, How much nitrogenous fertilizer can be applied without injury? In order to answer this an experiment was started in October, 1922. Uniform stools of H 109 cane, grown from single eye cuttings in small seed boxes were placed in large concrete pots.

In one series nitrate of soda was applied, in duplicate, in amounts ranging from 25 pounds nitrogen to 200 pounds nitrogen per acre. In another series ammonium sulphate was applied in amounts ranging from 50 to 200 pounds nitrogen per acre. Two pots were left untreated as a control. The first application of fertilizer was made approximately one month after planting. The above applications have been made each month making eleven applications to date. The cane receiving the heaviest applications of nitrogen in both forms has at times shown some signs of injury immediately following the fertilization. However, all the stools are still strong and healthy.

The drainage water from these tubs has been collected and analysed. Traces of nitrogen in the form of ammonia and nitrites have been leached out, but only moderate amounts of nitrogen as nitrate have been lost. The largest losses do not amount to more than 10 to 20% of that added. Evidently the soil or the crop has retained most of the nitrogen. The experiment shows that there is little danger of injuring the growth of cane plants by any application of nitrate of soda or ammonium sulphate which is likely to be made under field conditions. ✓

RETENTION OF NITRATES AND EFFECT ON SOIL REACTION

The study of nitrogen salts and their effect on the soil reaction, on which a preliminary report was issued last year, has been continued. In the preliminary work it was found that ammonium sulphate was perfectly retained until nitrification took place. The ammonia radical was held in the top foot of soil. Sodium nitrate was washed down into the second foot and third foot in most cases and occasionally into the fourth foot by a six-inch irrigation. All the nitrogen salts showed some solubility effect on the soil minerals. There was more effect from ammonium nitrate and ammonium sulphate in rendering plant food soluble than there was with sodium nitrate. Sodium nitrate and ammonium nitrate caused a slight increase in the alkalinity of most of the soils used. Ammonium sulphate showed the usual slight increase in soil acidity.

Since completing the above laboratory studies two series of field experiments have been carried out in which nitrate of soda was applied to three typical soils at Ewa Plantation. All applications were made at the rate of 100 pounds nitrogen per acre. The nitrate was largely retained in the top two feet of soil, some penetrated into the third foot, but very little went down into the fourth. In several cases the irrigation water passed down to an appreciable extent into the fourth foot of soil without taking a corresponding amount of nitrate with it. This shows a better retention of nitrates in the undisturbed field soil than when packed in lysimeters.

The first season's application was absorbed out of the soil by the plant in about ten weeks or less. The second season applications were taken up more slowly but were largely used up within three months after application.

With some soils there was a slight increase in alkalinity, but this gradually disappeared. This gradual disappearance of alkalinity developed from nitrate applications was also obtained in laboratory experiments, in which soils to which sodium nitrate applications had been made were retained at optimum moisture content in jars. The effect of mixed fertilizers upon the soil was found to be somewhat similar to nitrate of soda. This change in the reaction of the soil is probably due to the high content of colloidal material in our soils and the correspondingly low percentage of silicates. ✓

ORGANIC CARBON

Studies on the carbon content of plantation soils show considerable variation in the organic matter present. The carbon content ranges from 1.02% to 13.11%, being highest in the humid districts on Hawaii and lowest in the dry sections of Maui and Oahu. Results indicate that as compared to mainland soils, analysis does not show too low an organic content. Data on mainland soils, however, do not necessarily apply, as the physical condition and water holding capacity of the red clay type would undoubtedly be greatly improved by additional organic matter. The principal properties which organic matter impart to the soil are greater water holding capacity and improvement in mechanical condition.

Other than the coral areas there is little or no carbonate carbon present. All non-coral areas were below .025% carbonate carbon.

The question has often been asked, Are we exhausting the organic content of plantation soils? In an attempt to answer this a set of 42 samples from Ewa Plantation were analysed for total carbon content. The results obtained are of unusual interest. These 42 samples represent cropped and uncropped adjacent areas of nine fields. Of these nine fields, four were lower in carbon and five were higher than adjacent border samples. The field samples varied from .85 to 1.93% with an average of 1.30 while the border samples varied from .74 to 2.68% with an average of 1.37. In other words, at Ewa plantation where crops are heaviest and trash burning always practiced there is no indication that organic matter is being depleted. Roots and stubble are apparently keeping it up.

PAPER MULCH

Two of the principal factors involved in the stimulation of plant growth under paper mulch are temperature and moisture supply. Some experiments during the past year have added materially to our knowledge of the above properties of the mulch.

Temperature. Temperature records were made by standard soil and air thermometers. The differences between the soil with and without paper appear to depend on several factors. They vary with the general weather conditions and the temperature of the air. With bright clear weather and a fairly high temperature the temperature of the soil under paper may be 8 to 10 degrees F. higher at certain periods of the day. In general, in clear weather with tem-

peratures of 75° to 80° the difference will amount to 4° to 6° F. in the day time and 1° to 3° at night in favor of the paper. In cool rainy weather, these differences disappear and after a heavy rain the paper plot may have a lower temperature for a time as it warms up more slowly. Under half shade conditions the differences are much lower.

Evaporation. In this experiment it was found that the bare soil lost moisture three times as fast as the soil covered with paper. The paper covered soil lost the same amount of water in 18 days as the uncovered soil lost in 8 days.

BORAX IN FERTILIZERS

During the war, serious injury to field crops, from fertilizer applications, was noted on the mainland and traced to the potash salts which contained appreciable amounts of borax. This potash had been obtained from one of the emergency sources created following the cutting off of German commerce. In view of the fact that potash from this same source had been imported to Hawaii the question arose as to the toxicity of borax to sugar cane.

Experiments in concrete tubs comparing 50, 250, 500, 1,000, 2,000, 4,000, 8,000 pounds borax per acre indicate thus far a high degree of resistance of sugar cane to borax. On the plant crop no visible evidence of injury was noted with less than 1,000 pounds per acre and very little where 1,000 and 2,000 pounds were applied. On the mainland, amounts as small as 5 to 8 pounds per acre caused appreciable injury to potatoes, cotton, corn and tobacco.

PHOSPHORIC ACID AND POTASH IN CANE JUICES

The study of the relation of phosphoric acid and potash in cane juices to the available supplies in the soil which was started last year at Pioneer Mill has been continued there and taken up in some detail at Ewa Plantation. These results are being presented by J. H. Pratt. For this reason, only those results published in the Record during the year and some observations made at the Experiment Station will be mentioned.

Phosphoric Acid. The results published by Mr. Walker to date indicate .01% P_2O_5 in cane juice to be the point below which phosphate manures should be applied. Those above .02% contain sufficient available P_2O_5 in the soil. At the Experiment Station we analysed juices from separate plots in experiments carried out at Oahu Plantation and the Waipio Substation, in which we were studying the changes in available phosphoric acid in the soil. The former gave response and the latter no response to phosphates. This data is being prepared for publication along with the soil studies. Suffice it to say that the juice from Oahu Sugar Co. contained .008% P_2O_5 while that at Waipio contained .026% to .029%. The latter area is slightly higher in available phosphoric acid but not markedly so. The principal difference appears to be in the solubility of lime and silica in these two soils. Our studies indicate these factors to be closely related to the assimilation of phosphoric acid. This is further indicated by the fact that there was only a very slight increase in the P_2O_5 content of the juice on the fertilized plots.

Potash. Similar studies as published in the Record, also at Pioneer Mill, have shown quite a consistent relation between the potash in the juice and availability. However, with this element there appears to be a greater relative increase in assimilation on the fertilized plots. This would indicate a lesser influence of outside factors on the assimilation of potash. It is suggested from the results obtained at Pioneer Mill that a cane juice containing less than .05% K_2O indicates the need of potash fertilization, and one containing .10% does not. At the Experiment Station we have data also from Exp. 6, Oahu Sugar Co., and Exp. "V", Waipio, neither of which responds to potash. The juice from Waipio contained .12% K_2O while at Oahu it varied from .11 to .14%. From these experiments we failed to obtain any marked increase in the results from the potash fertilized plots. It amounted to only .01 to .02% as compared to .06% at Pioneer Mill and Olaa. ✕

SOIL ACIDITY

Attention has frequently been called to the acidity of Hawaiian soils which persists in spite of their basic character. For some time we have been studying the nature of soil acidity in Island soils with special reference to the role of iron, aluminum and manganese in governing this reaction and the role which they play in the fertility of the sugar lands. The first phase of this work has progressed very satisfactorily and produced some very interesting results.

Qualitative Tests for Acidity. A comparative study of a number of the qualitative tests for soil acidity produced three which appear to be well adapted to our soils. These include the litmus, Veitch and Comber methods. The latter method, involving the use of potassium sulphocyanate, being a new one, it may be well worth while to describe in some detail. Potassium sulphocyanate is extensively used in qualitative analysis as a test for ferric iron. Soluble forms of iron, aluminum and manganese are present in most acid soils, the higher the acidity the greater the amounts present. Comber found that on shaking an acid soil with the above reagent a red color developed while a colorless solution appears with alkaline soils. The delicacy of the test depends upon the solvent used and the most suitable form which we have found is a commercial article sold under the trade name "Rich or Poor."

Quantitative Tests. A study of all the well known methods of quantitatively determining soil acidity or lime requirement produced a most bewildering array of results. These have been published recently in the Record, so suffice it to say that the Veitch is as good as any. A determination of the solubility of lime in water saturated with carbon dioxide agreed very closely with the reaction of the soil and did so consistently. The latter method shows very clearly the definite association of lime with the reaction of our soils and indicates that further value might be attached to this method on more extensive application. It is at least the most promising, other than the hydrogen ion determination by the hydrogen electrode or colorimetric methods.

Nature of Acidity. Results obtained thus far indicate aluminum salts and aluminosilicates to be the principal factors associated with the acidity of our soils. These compounds are present in most soluble forms in the soils from the humid districts such as the Hamakua Coast and the upland areas on the other

Islands. Acid-reacting organic matter also appears to be a factor in the solubility or activity of these compounds. In the lowland districts these factors are strongly involved in the acidity of poorly aerated areas. In the poorly aerated soils there is usually found a greater solubility of iron and manganese. Iron appears to be a factor only in the very acid soils, while a low acidity appears to be typical of the manganese soils. Both the latter play a secondary role to aluminum. Our studies indicate further that the availability of iron in the manganese soils is just as great as in the non-manganiferous soils of equal acidity but that solubility of iron and acidity run hand in hand.

Relation to Fertility. Since Abbot, Conner and Smalley, at the Indiana Experiment Station published results in 1913 showing the relation of low root vitality in corn with soil acidity, which latter they attributed to the presence of hydrolyzable salts of aluminum, considerable attention has been given to the influence of this factor in soil fertility problems. A review of this work is obviously outside the scope of this report. Suffice it to say that aluminum salts themselves have been shown to be toxic toward certain plants as well as being associated with acid reacting soils. As stated above, our studies have shown aluminum salts to be one of the principal factors involved in the acidity of our soils. Also the presence of soluble aluminum salts has been noted. The logical question arises as to the association of inhibited root development of sugar cane, as well as pineapples, with this soil condition. The progress of this phase of the work has not developed sufficiently to draw definite conclusions but it may not be amiss to cite certain observations.

At the Rhode Island Experiment Station, where a method has been worked out for determining the so-called "active" aluminum in soils, those containing more than 225 parts per million were found to be associated with low root vitality when cropped to plants toward which aluminum salts are known to be toxic. With few exceptions acid Hawaiian soils are above this figure and several upland fields where root vitality is low have shown considerably higher aluminum content as determined by the above method. The Hamakua coast soils where Lahaina first failed, are uniformly high in soluble forms of aluminum. Also the high organic and moisture content of these soils are conditions which have been found to be associated with a greater solubility of aluminum. The pineapple lands, also being upland areas are likewise located in such an environment. Evidence is therefore not lacking, indicating the low vitality of sugar cane and pineapples in some districts, to be associated with toxic amounts of aluminum salts. This is further indicated by the almost universal response of upland soils to phosphate fertilization, low phosphate availability being usually associated with the presence of soluble aluminum salts.

As for the toxicity of aluminum salts toward sugar cane, in water and sand cultures we find aluminum sulphate shows considerable toxicity and preliminary investigations indicate less resistance in the Lahaina variety.

Chemical methods of determining toxic amounts of aluminum in our soils have not thus far produced any very encouraging results. Like the application of many analytical methods to our soils, this factor will probably require some study before we are able to actually prove or disprove the presence of toxic

amounts of aluminum. * This in spite of the fact that we are able to definitely show its presence.

The principal corrective agents for such soil conditions are liming and heavy phosphate applications. To date, pot experiments on a soil from a field at Hono-kaa where even D 1135 showed indications of root-rot, have responded markedly to heavy phosphate applications using Lahaina seed. ✓

Report of the Committee on Phosphoric Acid and Potash Determinations in Cane Juices*

BY J. H. PRATT

The determination of potash and phosphoric acid in crusher juice as an aid in finding the fertilizer requirements of the different fields was suggested by H. S. Walker in the *Planters' Record*, Vol. 26, pages 317-321, and Vol. 27, pages 112-115. During the past year this has been made part of the regular laboratory routine at Ewa and Pioneer Mill and preliminary work has been done at several other plantations. As over two thousand determinations have been made, enough data has been accumulated to enable us to draw some very interesting conclusions and comparisons. Some of these are, perhaps, little more than surmises and subsequent work may disprove them; others, however, have enough confirmation to seem definitely proven. It should be remembered that these are based on only *one* year's work on only *two* plantations. Conditions at Ewa and Pioneer Mill are obviously dissimilar with regard to soil, cane, and water conditions and it is interesting, therefore, to see in how many cases the same conclusions have been reached.

The methods of analysis, as given in the *Planters' Record* have been followed, except that the results have been calculated on the basis of "per 100 solids (Brix) in juice" rather than on "grams per 100 c.c. of juice." The potash figures from Ewa are given on basis of "grams per 100 grams of juice," otherwise, except where noted, all figures for both P_2O_5 and K_2O are given on the new basis. This is felt, by both W. P. Alexander and the writer, to be a more logical method of comparison, as the density of the juice may vary considerably at different seasons of the year, altho as Mr. Alexander says, "If the data were available, percent on the weight of the ash would be still more accurate."

EFFECT OF LOCATION OF THE FIELD ON POTASH AND PHOSPHORIC ACID

At Ewa, the fields which yield a juice with low potash content are, with two exceptions, concentrated in a very definite area—the very heavy soils above the mill site—and they find that a **lack** of potash in the soil (with the corresponding deficiency in the juice) is related in many instances to poorly drained areas. The fields below the mill, which are irrigated with mill waste water often containing mudpress cake and molasses, and the makai fields in the Waimanalo section are

* Presented at the Second Annual Meeting of the Association of Hawaiian Sugar Technologists, Honolulu, October 22, 1923.

Chart I

EWA PLANTATION CO.

8 Chart illustrating the correlation
7 between Percentage of Potash in the
6 cane juice from each field and the
5 potash content of the soil.

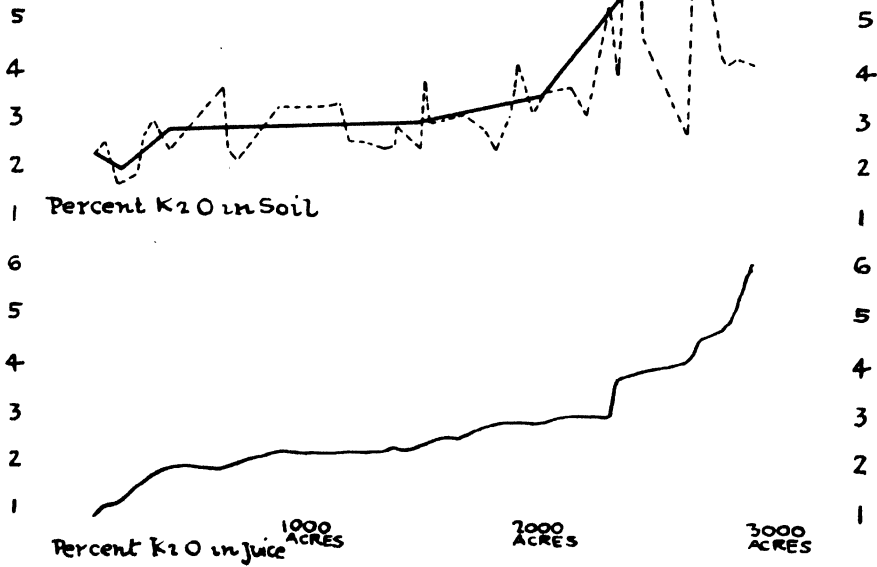
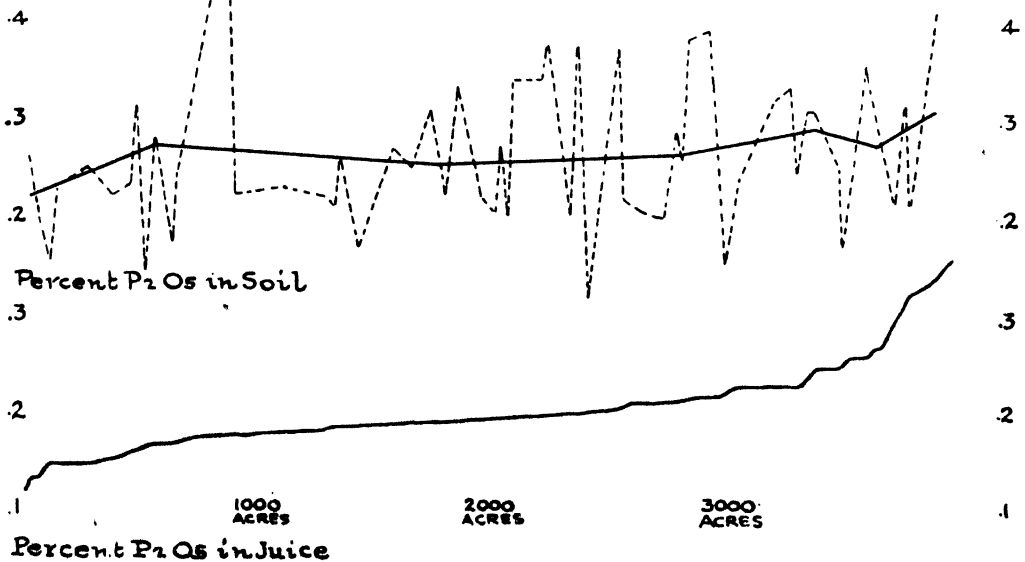


Chart 2

EWA PLANTATION CO.

The Range of P_2O_5 in the Cane Juice from each field
and the corresponding total P_2O_5 in the soil



the highest in potash. Those lowest in P_2O_5 are scattered from one end of the plantation to the other, being the highest fields in the Waimanalo section and the lowest in the Honouliuli section. There seems to be some evidence that cane grown on land "made" rather recently from the deposit of storm waters, gives a juice low in P_2O_5 . This is in spite of an excellent growth on all these so-called "waste ditch soils."

At both Oahu and Pioneer Mill, where there is a considerable difference in the elevation between the high and the low fields, the elevation is a most important factor. H. W. Robbins says, "Our results show a fairly regular drop in P_2O_5 from fields at a lower elevation to those at a higher elevation, and a very marked difference between extreme low and high elevations." That the same is true at Pioneer Mill is shown by the following averages for our main groups of fields:

TABLE NO. 1

Field	Elevation Approximate	P_2O_5		K_2O	
		Samples	%	Samples	%
A	900'-1250'	10	.051	4	.827
B	350 - 900	60	.071	50	.902
C	75 - 350	37	.115	29	2.055
D	below - 75	23	.214	19	1.679
E	900-1900	15	.053	12	.798
F	550 - 900	30	.052	28	.789
G	400 - 550	18	.058	17	.562
H	200 - 400	29	.098	25	1.640
I	below - 200	14	.212	6	1.864
LA	525-1450	31	.066	31	.684
LB	275 - 525	39	.113	36	.875
LC	100 - 275	48	.191	46	1.494
LD	75 - 100	24	.188	23	1.774
O	below - 75	55	.233	48	1.840
MA	350 - 800	6	.074	..	....
MB	250 - 350	13	.115	13	1.002
MC	100 - 250	10	.202	5	1.767
MD	below - 100	8	.209	4	2.032
30-34	up to - 700	51	.050	46	1.288

These groups of fields are in long narrow strips running more or less horizontally, with the upper and lower boundaries usually following the contour, and on the average two miles long by from one-fourth to one mile wide. In the Honokawai section (Fields 30 to 34) where the fields run the other way—from mauka to makai—the samples from the bottom of the field were much higher in both potash and P_2O_5 than those from the middle of the field, while those from the upper end were still lower.

COMPARISON BEWTEEN SOIL AND JUICE ANALYSES

At Pioneer Mill we are fortunate in having about forty soil analyses of recent date and representing almost all of our principal groups of fields. In the following comparison, the figures have been arbitrarily divided into four classes in the case of P_2O_5 , and five classes in the case of the potash, which classes for the sake of convenience have been called "high", "good", "intermediate", "fair" and "low".

TABLE NO. 2.

 P_2O_5 .

Crusher Range	Juice Fields	Citrate Range	Sol. x 10 Fields	HCl Range	Soluble Fields	Total Range	Fields
.0 - .06	A, E, F, G, 30	.00-.05	A, E, F, G, 30, B, H, MB	.00- .9	F, G, LA, LB	.1½-.2½	E, F, MB
.07- .12	C, LA, LB, B, H, MB	.05-.10	C, LA, LB, I, MC	1.0 -1.2	E, H, MB, 30	.2½-.3	G, H, MB, MD, LA, LD, 30
.13- .18	None	.10-.15	None	1.3 -1.5	B, C, D, I, MC	.3 - .3½	B, C, D, I, MC
.19- .24	O, LD, MD, D, I, MC	.15 up	D, LD, MD, O	1.6 up	A, LD, O, MD	.3½ up	A, O

Potash

.0 - .7	G, LA	.0 - .2	G	.0 - .15	F, LA	.0 - .3	F, G, LA, LB, MC
.7 -1.0	A, B, E, F, LB, MB	.2 - .3	E, F, H, MC, 30	.16- .2	A, C, D, E, O, LB, MC	.3 - .4	D, E, O, LD, MB, MD
1.0 -1.5	30	.3 - .4	A, C, I, O, LA, LD	.21- .26	G, LD	.4 - .5	C, H, I
1.5 -1.8	D, LD, MC	.4 - .5	B, D, LB	.26- .30	H, I	.5 - .6	A
1.8 -2.5	C, H, I, O, MD	.5 up	MB, MD	.31 up	B, MB, MD, 30	.6 up	B, 30

TABLE NO. 3—CLASSIFICATION OF FIELDS

Field	P_2O_5					K_2O				
	Juice	Citrate	HCl	Sol. Total	Ave.	Juice	Citrate	HCl	Sol. Total	Ave.
A	low	low	high	high	low	fair	int.	fair	good	int.
B	int.	low	good	good	int.	fair	good	high	high	?
C	int.	int.	good	good	int.	high	int.	fair	int.	
D	high	high	good	good	high (—)	good	good	fair	fair	good (—)
E	low	low	int.	low	low	fair	fair	fair	fair	fair
F	low	low	low	low	low	fair	fair	low	low	fair (—)
G	low	low	low	int.	low	low	low	int.	low	low
H	int.	low	int.	int.	int.	high	fair	good	int.	?
I	high	int.	good	good	good	high	int.	good	int.	int.
LA	int.	int.	low	int.	int.	low	int.	low	low	low
LB	int.	int.	low	int.	int.	fair	good	fair	low	fair
LD	high	high	high	int.	high	good	int.	int.	fair	int.
O	high	high	high	high	high	high	int.	fair	fair	?
MB	int.	low	int.	low	low-int.	fair	high	high	fair	fair-high
MC	high	int.	good	good	good	good	fair	fair	low	fair
MD	high	high	high	int.	high	high	high	high	fair	high
30-34	low	low	int.	int.	low-int.	int.	fair	high	high	?

In the case of the P_2O_5 , there is a fairly close agreement between the crusher juice and citrate soluble classifications; twelve of the fields fall into the same classification and three of the other five into the next class.

With the exception of the "A" fields, there is also a fair agreement between the juice analysis and the "HCl soluble," and also the total P_2O_5 . With the potash, the agreement is not so close. Some of the fields check very well, but others are considerably off. It should be remembered that in many cases there is only one soil sample from a group and that the juice may have come from cane at a considerable distance from the place where the soil sample was taken.

Chart 1

PIONEER MILL CO. LTD.

Comparison of P_2O_5 in Juice
with the Citrate Sol. P_2O_5 in Soil

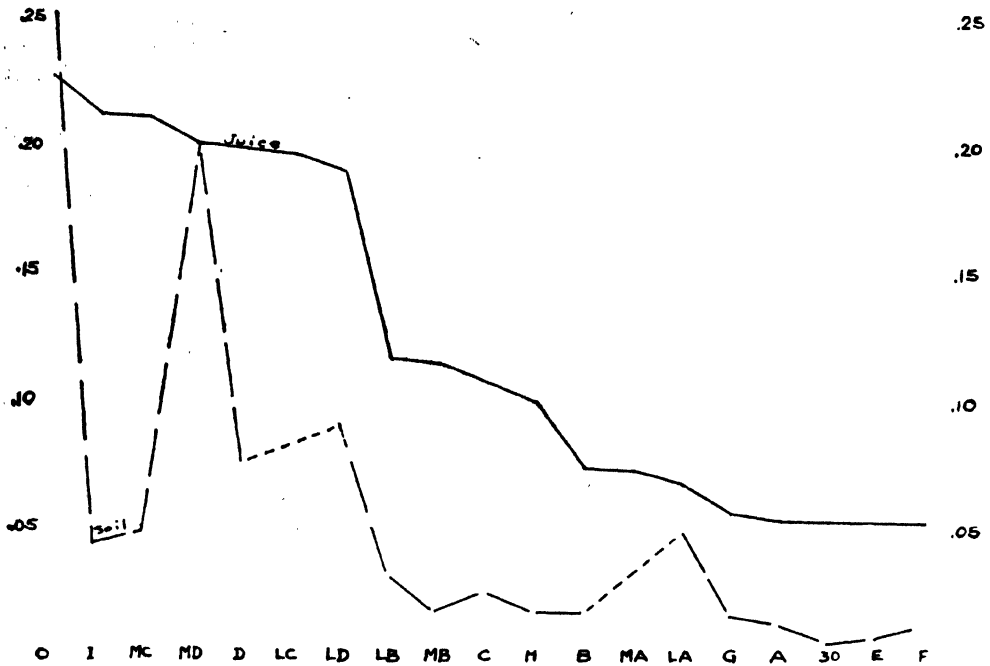
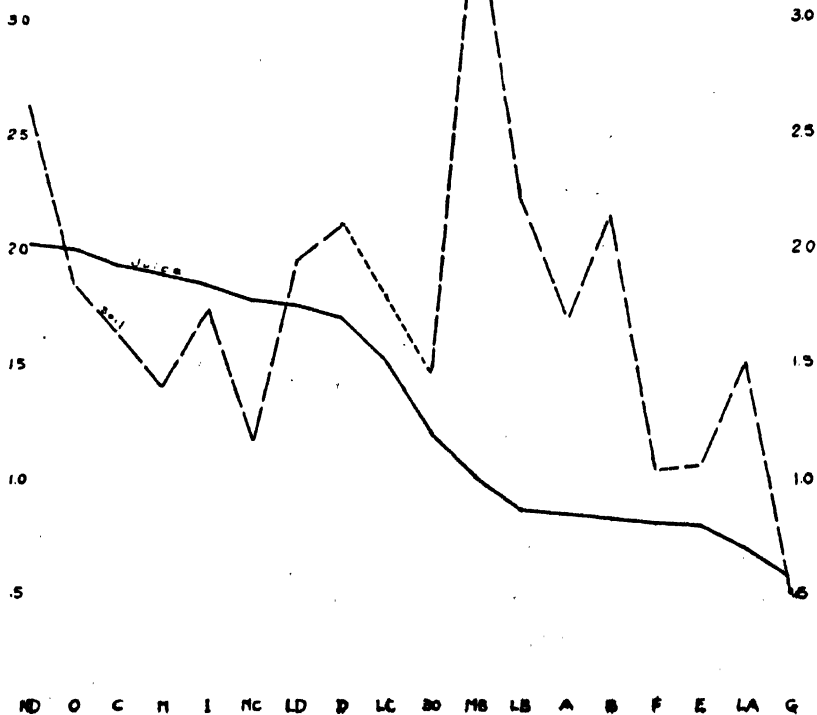


Chart 2.

Comparison of K_2O in Juice with the
Citrate Soluble K_2O in Soil

PIONEER MILL CO. LTD.



An interesting point in this connection is, that the "G" fields are the lowest in potash of any fields on the plantation both in soil analysis and in the juice determinations, altho, judging from their location, they should be higher than the "F" and "E" fields.

At Ewa, Mr. Alexander finds that the percentage of potash in the juice is related to both the soil analysis and the need of the cane for potash. Chart 1 brings out clearly that the percentage of potash in the juice is directly correlated with the amount of potash present in the soil. There is a variation in soil analyses from field to field, but the averages show a steady climb as the amount of potash in the juice increased. In regard to P_2O_5 , he says, "The number of soils analyzed recently is not sufficient to draw conclusions as to the possible correlation between the amount of phosphoric acid in the soil and that percentage which appears in the juice." Using some total P_2O_5 (HCl digestion) determinations made at Ewa over twelve years ago in combination with a few of the more recent analyses made by the plantation, one sees that while there is a tendency for the phosphoric acid in the juice and soil to parallel each other, the individual variations are so great that the data are hardly indicative of what seems true for potash. It is possible that the citric acid soluble P_2O_5 would offer a better means of comparison.

YIELD PER ACRE AND QUALITY OF THE JUICE

There is no direct relationship between the percentages of potash and phosphoric acid and either the tons of cane per acre or the tons of sugar per acre; some of the individual fields which are lowest in one or both of these ingredients yielded twenty tons of cane per acre more than the average. The following table shows that there is a tendency for the high P_2O_5 fields to have a higher yield than those which are lower in P_2O_5 , but the same does not seem to hold true for potash:

TABLE NO. 4

	Fields	P_2O_5			Fields	K_2O		
		TC/A	TS/A	TC/TS		TC/A	TS/A	TC/TS
High.....	16	61.39	7.02	8.75	31	57.56	6.52	8.83
Good	25	54.13	6.55	8.26	16	51.25	6.13	8.36
Intermediate . . . . .	..	....	...	...	15	54.54	6.81	8.01
Fair	37	51.82	6.54	7.93	24	51.72	6.75	7.66
Low	18	51.47	6.85	7.51	10	54.09	7.23	7.48

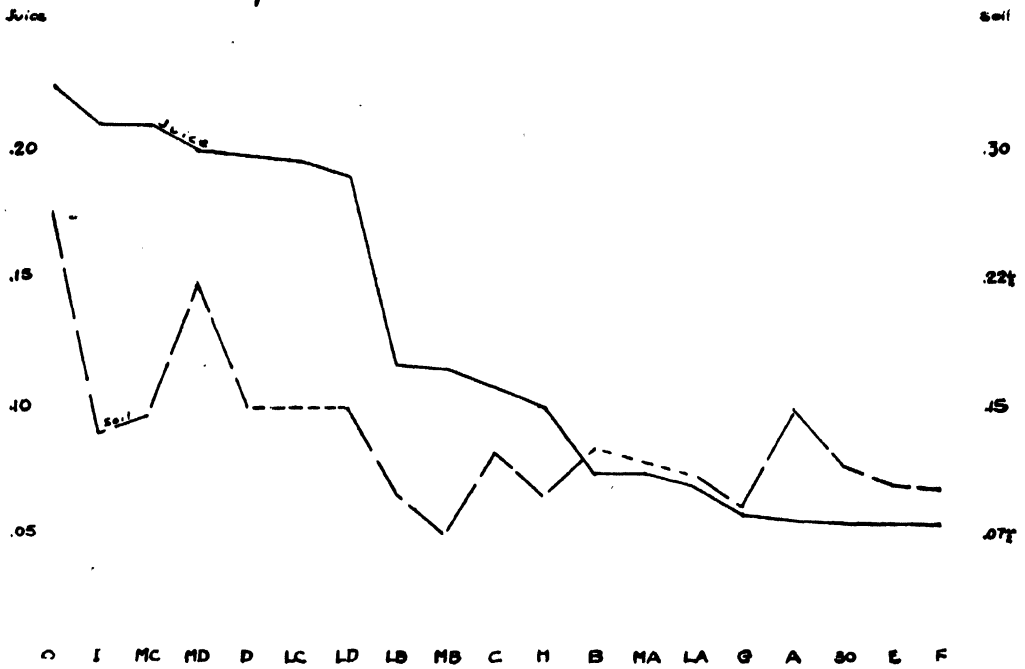
It is interesting to note the steady increase in the TC/TS as the potash and phosphoric acid increased.

EFFECT OF ADDING K_2O AND P_2O_5 TO THE SOIL

Mr. Alexander finds at Ewa that, "Phosphate fertilizers do not act so as to increase the P_2O_5 content of the juice. There is definite proof of this contention." The average of a number of tests at Ewa show .0380 grams of P_2O_5 per 100 c.c. of juice from the plots which received 100 lbs. to 200 lbs. of P_2O_5 , against an average of .0379 for the check plots. We have also found the same to be true at Pioneer Mill and several examples are given in Table No. 5.

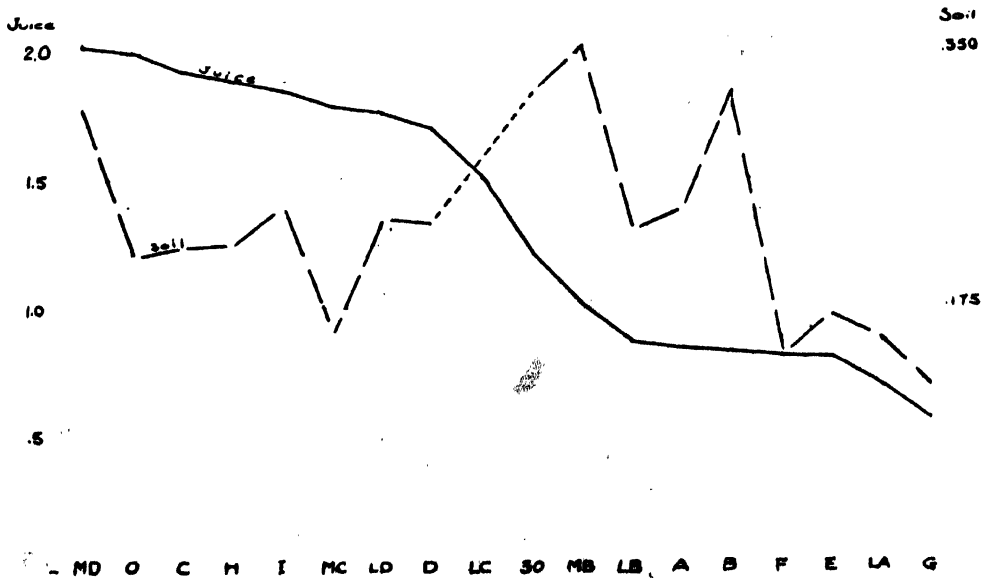
Pioneer Mill Co. Ltd.

Chart 3

Comparison of P_2O_5 in Juice and Soil

Pioneer Mill Co. Ltd.

Chart 4

Comparison of K_2O in Juice and Soil

With regard to potash at Ewa, they find that, "The data secured is very inconclusive." In some cases there was a small increase, in others a decrease.

At Pioneer Mill, with the exception of an experiment in field B6, we have found a small but definite gain of K_2O in the juice from potash fertilization. The same was also found in a potash experiment at Olaa, several sticks from each of thirty-two plots being sent to Lahaina for analysis.

TABLE NO. 5

Potash and P_2O_5 Experiment				P_2O_5 Experiment			
	% P_2O_5	% K_2O	Treatment		% P_2O_5	% K_2O	Treatment
Field B6....	.055	1.057	None	Field B6....	.062	.949	None
St. Mex.....	.057½	.833	100 lbs. each	St. Mex.....	.058	.937	375 lbs. P_2O_5
	.054	1.029	100 lbs. K_2O		.062	1.069	625 lbs. P_2O_5
	.053	.960	100 lbs. P_2O_5		.057	.793	875 lbs. P_2O_5
K_2O and P_2O_5 Experiment				K_2O and P_2O_5 Experiment			
	% P_2O_5	% K_2O	Treatment		% P_2O_5	% K_2O	Treatment
Field 31.....	.006	.363	None	Field B2....	.003	.690	None
H 109.....	.006	.398	100 lbs. P_2O_5	H 109.....	.003	.741	50 lbs. P_2O_5
			50 lbs. K_2O				100 lbs. K_2O

POTASH EXPERIMENT AT OLAA

K_2O	% K_2O								Ave. %
None . . . . .	.243	.355	.194	.189	.192	.156	.287	....	.231
100 lbs. . . . .	.493	.335	.376	.236	.313	.232	.297	.332	.511
150 lbs. . . . .	.434	.553	.367	.355	.368	.289	.314	.528	.401
200 lbs. . . . .	.582	.419	.603	.381	.468	.424	.547	.439	.483

The experiments from field B6, were sampled at the mill in car load lots and analysed in duplicate. The experiments in 31 and B2 not being quite mature, two sticks were taken from each plot and ground in a hand mill. Five repetitions in 31 and four in B2 were each analysed in duplicate or triplicate. The potash determinations on the cane from Olaa were made in triplicate. The results are, therefore, accurate. A small observation test has been started at Pioneer Mill in a field very low in both potash and phosphoric acid, in which these ingredients have been applied in various forms in very heavy doses to small areas.

EFFECT OF VARIETY OF CANE

So far, we have been unable to establish any regular difference in potash and phosphoric acid between the different varieties of cane. Any such difference that may exist is not sufficient to overcome local soil variations. Comparing the different fields at Pioneer Mill, H 109 averages higher (.126 against .117) than Lahaina in P_2O_5 , and also in potash (1.322 against 1.117). H 109 is also slightly higher than Striped Mexican in P_2O_5 (.119 against .109), but about the same in K_2O (1.282 against 1.286). H 109 is lower than D 1135, both in P_2O_5 (.130 against .135) and in K_2O (1.341 against 1.661). At Ewa where Lahaina cane had been replanted with both D 1135 and H 109, it was possible to obtain samples

Chart 5

PIONEER MILL CO. LTD.

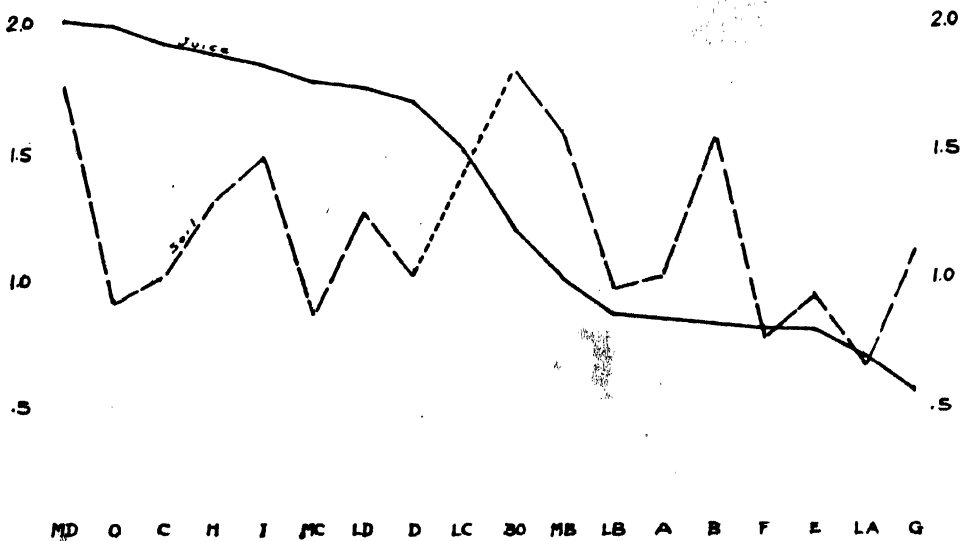
Comparison of P_2O_5 in Juice with
the HCL Sol. P_2O_5 in Soil



Chart 6

PIONEER MILL CO. LTD.

Comparison of K_2O in Juice with the
HCL Soluble K_2O in Soil



of these three varieties from less than five running feet of line. These gave D 1135 .020 grams P_2O_5 per 100 c.c., H 109 .014, and Lahaina .011. In another field, H 109 showed .319 and Yellow Caledonia .280%. Similar small samples from fields at Pioneer Mill showed:

Field 34 Plant	Lahaina	St. Mex.	D 1135	H 5919	H 456	H 109	Red Seedling
P_2O_5 . . . . .	.005	.004	.005	.004	.004	.004	.005
K_2O . . . . .	.238	.268	.315	.231	.310	.151	.180

Field LB-2	St. Mex.	H 5919	H 456	Field K-1	St. Mex.	H 109
P_2O_5 . . . . .	.010½	.009½	.010½	P_2O_5	.152	.168
K_2O . . . . .	.155	.204	.140	K_2O	.698	.608

Field O 7	Yellow Cal.	Rose Bamboo	Lahaina	St. Mexican
P_2O_5 . . . . .	.061	.049½	.051	.039
K_2O . . . . .	.383	.313	.222	.187

The above figures, except those from field K-1, are on the basis of grams per 100 c.c. of juice.

EFFECT OF TIME OF CUTTING

Results from the main groups of fields at Pioneer Mill seem to indicate that there is a tendency for the percentages of potash and phosphoric acid to vary with the time of cutting, being highest in P_2O_5 in February or March and highest in K_2O in December. The results from the different groups of fields are fairly consistent; February, for instance, being higher in P_2O_5 than the other months in 34 out of 45 comparisons.

	December	January	February	March	April	May
P_2O_5 . . . . .	.105	.115	.136	.135	.129	.113
K_2O	1.704	1.544	1.161	1.237	1.093	1.050

The age of the cane also has an effect on the percentage of K_2O and P_2O_5 as shown by the following analyses. In all the eight cases given below, the "suckers" were higher in both K_2O and P_2O_5 than primary sticks from the same stool. The first four samples were from H 109 cane twelve months old, the next two from H 109 cane sixteen months old, the last two from Striped Mexican of the same age.

		Old Sticks		Suckers	
		% P_2O_5	% K_2O	% P_2O_5	% K_2O
Field O-2	H 109 cane	.174	1.492	.254	2.706
do		.156	1.288	.221	2.144
do		.170	1.492	.317	4.247
do		.161	1.411	.238	2.326
Field K-1	H 109 cane	.212	0.652	.314	2.709
do		.123½	0.564	.171	1.450
do	Str. Mexican	.157	0.719	.165	2.028
do		.148½	0.676	.217	2.006
Average . . . . .		.163	1.037	.237	2.452

PLANT VS. RATOONS

There also seems to be a tendency for the plant cane to be lower in both P_2O_5 and K_2O than the ratoon cane at Pioneer Mill. The average for the entire plantation and for each of the four sections gave lower results for plant than ratoons. In fourteen out of twenty-one cases in which both plant and ratoon cane was growing in the same or adjoining fields, the ratoon cane was the higher in both potash and phosphoric acid. The averages were .103 % P_2O_5 for plant and .112 for ratoons, and 1.122 % K_2O for plant and 1.296 for ratoons. This difference is perhaps too slight to be very conclusive.

Long ratoons are lower in P_2O_5 and higher in K_2O than short ratoons in six out of eight comparisons. The averages are long ratoons .194 % P_2O_5 , short .214%, long ratoons 1.740 % K_2O and short 1.410.

CONTENT OF DIFFERENT PARTS OF STALK

In a test of 12 mature stalks of cane divided into thirds and ground in a hand mill, Alexander finds:

Top of stick.....	.0800	% P_2O_5	.063	% K_2O
Middle of stick.....	.0864	"	.042	"
Butt of stick.....	.1138	"	.010	"

VARIATION WITHIN A FIELD

While the averages for the different fields are consistent, the individual samples from some of the fields may show considerable variation. Mr. Alexander finds that at Ewa, "The more uniform the contour and type of soil, the smaller the individual range between the individual samples of the juice," and he concludes, that it is necessary to obtain six samples from each field to insure an accurate average. The following figures show the variation in some of the Ewa fields:

Field	Area	No. of Samples	Percent K_2O in the Juice		
			Average	High	Low
20-A	53.48	11	.101	.165	.055
11	58.30	6	.104	.177	.019
14-B	76.84	7	.144	.217	.073
15-B	126.06	9	.214	.352	.092
2-A	105.75	8	.214	.372	.115
28-A	146.25	7	.248	.352	.192

Very few of the fields at Pioneer Mill show anywhere near this amount of variation in the potash, and the amount of variation in the phosphoric acid is considerably less. On the other hand, some of the fields run remarkably consistent to the average. Five samples from LB5P, for example, showed .092, .098, .097, .094 and .094 % P_2O_5 , one of the samples was from cane ground in December and the other four from cane ground in March. The three samples from O 11L gave .267, .267, and .267 % P_2O_5 and 1.91, 1.89, and 1.90 % K_2O . The amount of variation between stools is shown by the figures given above to show the difference between "suckers" and primary sticks; the four stools in O-2 being

Chart 7

PIONEER MILL CO. LTD.

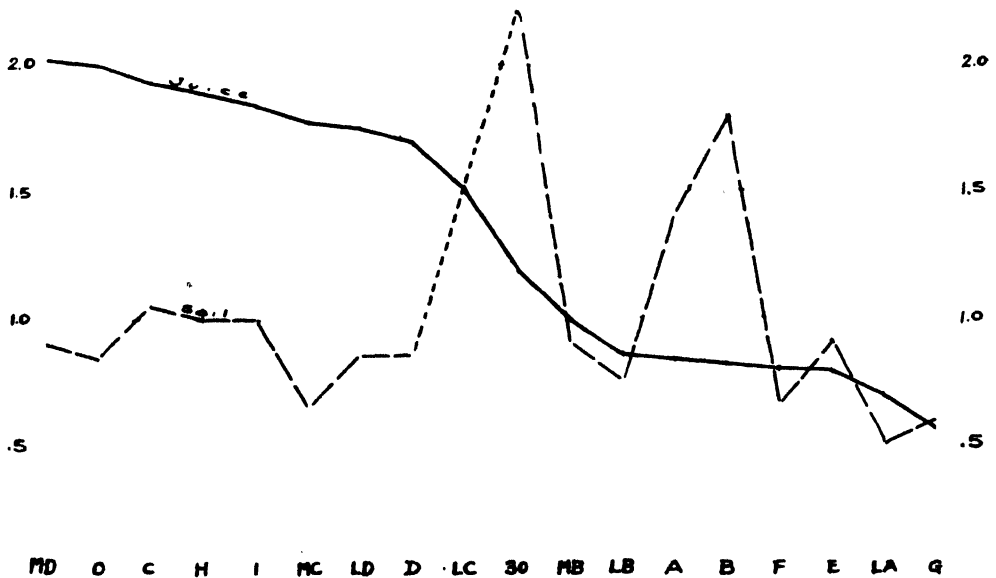
Comparison of P_2O_5 in Juice
with the
Total Sol. P_2O_5 in Soil



Chart 8

PIONEER MILL CO. LTD.

Comparison of K_2O in Juice with the
Total Soluble K_2O in Soil



located very near each other, the first H 109 and first Striped Mexican stools being adjoining, and the same being true of the second H 109 and Striped Mexican stools.

ACCURACY OF METHOD OF ANALYSIS

The following duplicates made on the same samples at different times show the degree of accuracy of the Sherrill method. The results are calculated on the basis of "% on weight of juice" and none of the samples were concentrated.

Yellow Caledonia.....	.379 & .386	Rose Bamboo .....	.312 & .313
Lahaina . . . . .	.219 .225	St. Mexican.....	.175 .199
Lahaina . . . . .	.235 .240	H 109 .....	.151 .151
Field C-10 .....	.249 .252	St. Mexican.....	.267 .269
D 1135.....	.309 .321	H 456.....	.307 .312
Red Seedling.....	.174 .186	H 5919.....	.228 .233

Average of 12 trials, low sample .252, high sample .259, difference .007. Another set all made on Yellow Caledonia cane shows about the same degree of accuracy:

1....	.052	.051½	.048½	....	....	17....	.088½	.088½	.....
2....	.074	.074	.080	....	....	18....	.115½	.115½	.....
3..	.046	.044	.040	.040	.042	19....	.077	.079	.084½
	.034	.048				20....	.063	.061	.....
4....	.038½	.037	....	....	....	21....	.081	.075	.074½
5....	.043	.044	.033	.044	....	22....	.074	.074	.....
6....	.029½	.031½	.034	....	....	23....	.063½	.066	.069
7....	.058	.056	.054	.067	.066	24....	.113	.113	.111½
8....	.068	.071	.062	....	....	25....	.083½	.080	.075
9....	.046½	.047½	....	....	....	26....	.100	.097	.093½
10....	.063	.062	.062	....	....	27....	.087	.090	.090
11....	.070	.070	.067	....	....	28....	.091	.096	.092½
12....	.111	.112	.112	....	....	29....	.106	.108	.102
13....	.109	.101	.098	....	....	30....	.128½	.126	.....
14....	.072	.072	....	....	....	31....	.091	.091	.....
15....	.081	.083	.077	....	....	32....	.131½	.130	.....
16....	.052	.052	.050	....	....		

The phosphoric acid method is even more accurate. During the year a few samples were encountered which gave some difficulty. These were all either from Yellow Caledonia cane or from a field which was exceptionally low in P_2O_5 . Any person familiar with the method and using proper care should get results checking within .001 or .002 grams P_2O_5 per 100 c.c. and it is easily possible to get closer than this if necessary.

CONCLUSIONS

1. The methods of analysis for potash and phosphoric acid are simple and easily made part of the laboratory routine.
2. There is considerable variation in the P_2O_5 and K_2O content of the crusher juice depending upon the location of the field.

3. There is a correlation between the juice and soil analyses.

4. There seems to be a tendency for fields having high percentages of P_2O_5 in the juice to have a higher yield of cane, altho this is by no means proven. There is also a tendency for cane high in K_2O and P_2O_5 to have a higher quality ratio.

5. Adding phosphate fertilizers does not increase the P_2O_5 content of the juice, but adding potash fertilizers does increase the percentage of K_2O .

6. There is not much difference between H 109, Lahaina, and Striped Mexican in the P_2O_5 and K_2O content, but D 1135 seems to be slightly higher.

7. There seems to be a slight difference in the percent of K_2O and P_2O_5 in the juice at different times of the year.

8. Plant and ratoon cane may have different percentages of K_2O and P_2O_5 , plant cane being the lower. This difference is too small to be conclusive. There is a larger difference between long and short ratoons.

9. The upper end of the stick contains the largest amount of K_2O and the smallest amount of P_2O_5 .

10. There is considerable variation between the different samples in some fields, while others run very uniformly. This is dependent on the contour and the variation of the soil.

The practical application of this comprehensive collection of data is to decide whether the determination of potash and phosphoric acid in the cane juice offers a reliable source of information as to the available supply of these elements in the soil.

If the data obtained is found to be trustworthy, another link has been added to the chain of evidence which gives us a better understanding of the forms of fertilizer it is best and necessary to apply.

While the results secured during 1923 for one crop are, therefore, preliminary, certain correlations have been made which give this first year's work real value.

In conclusion I wish to express my thanks to Mr. H. E. Starratt, Mr. H. W. Robbins, and especially to Mr. W. P. Alexander, much of whose report on this subject has been copied verbatim.

Report of the Committee on Cultivation and Weed Control*

BY H. E. STARRATT

Cultivation and weed control in the sugar cane industry is of less importance on the irrigated than on the unirrigated plantations. On the former, the artificial application of water, with abundance of sunshine, forces the cane into such rapid growth that the weeds are smothered out, thus eliminating the necessity for weed control. On the unirrigated plantations the high percent of cloudy days, with excessive rainfall, 100 to 300 inches per annum, causes a slow growth of cane; so the shading out of weeds does not take place at such an early date. In order to control the weeds, artificial means have to be resorted to.

Cultural operations for weed control on the irrigated plantations are of minor consideration. Most of the cultivation done is in preparation for planting. This article deals more especially with cultivation in preparation for planting and weed control on unirrigated plantations.

Owing to labor difficulties, and the necessity for lessened cost of production, all of the operations could not be performed, so experiments were conducted to determine their value in cane production. Conclusive tests have not yet been conducted in all of the operations, however, experiments that have been made will be given when they are at hand, in following through the procedure.

PLANT CANE

Preparing for Planting: The seed bed, by popular opinion, should be the best that implements can make. In recent years, modern appliances, the tractor, types of plows, subsoilers, harrows, and cultivators, have been introduced to the field with apparent good results. These are improvements over the slow mule drawn implements, as the element of speed helps greatly to pull up the old cane stools and pulverize the soil.

Burning: The first operation, after harvesting a field that is to be planted, is usually to burn all of the refuse, but now with a well sharpened disc plow even a moderate amount of trash may be turned back to the soil when the old stools are plowed out.

Plowing: The irregularities of the fields of the unirrigated plantations do not permit the use of the steam plow that is used so successfully on irrigated plantations. Formerly, on the former plantations, implements were drawn by mule power, but now tractors greatly facilitate the field work. With these, new types of plows have been introduced. The most notable of these has been the adoption of the disc plow in preference to the mould board.

Harrowing: Following a period of weathering, the field is harrowed with a modern Kilifer harrow, tractor drawn, or with the old heavy frame tooth harrow.

* Presented at the Second Annual Meeting of the Association of Hawaiian Sugar Technologists, Honolulu, October 22, 1923.

Subsoiling: If there is a depth of soil, there is an implement that reaches down 18" to 24" and breaks up any hardpan or packed earth and opens up new areas for drainage and root extension. This implement, the Kilifer Subsoil Plow, does not turn the soil over, but by the use of a vertical bar with a short cross arm simply breaks up the subsoil without bringing it to the surface.

Lime: Where it is a practice to lime the fields it may be done just before the second plowing. There is no fixed amount or kind of lime used, but a popular practice is to add 8 to 10 barrels of ground Waianae lime per acre. The application may be up to a ton of hydrated lime per acre, or caustic lime may be added in lesser amounts. Several years ago successful experiments were conducted with the application of coral sand at the rate of two to four tons per acre.

Lime Experiments—Hamakua Mill Company: "No well defined gains are shown from the residual effects of lime applications at Hamakua Mill Co. In these experiments, reported two years ago, liming failed to show to advantage. The plots were again harvested in 1920, without further treatment, to determine if there was any after benefit. The yields are summarized as follows:

First Experiment	Cane	Sugar
Average all limed plots.....	26.7	3.53
Average all no lime plots.....	26.5	3.52
Second Experiment		
Average all limed plots.....	20.8	2.63
Average all no lime plots.....	19.2	2.43

"These experiments were conducted under drought conditions."¹

A report of 1923 states, "A liming experiment at Kaiwiki Sugar Company showed no gain at all for the lime used."²

Lime does not act alone as a fertilizing agent, but when subsequent applications of nitrogenous fertilizers are applied, nitrification is accelerated, and where potash is a limiting factor of cane growth, there is higher availability in the presence of lime, so the gains where they occur might be due to the potash alone.

Coral Sand, 2 tons—Olaa 1911 and 1913 (Residual effect):

Fertilizer	Yield of Cane		Cane per Acre	
	Sand	No Sand	1911	1913
500	40.6	37.4	Sand plats	49.9
1000	51.6	40.0		
1500	57.7	51.2		
			No sand	45.9
				40.5

Olaa soils respond to potash fertilization, so part of this gain may have been due to the liberated potash.

Lime carbonate causes the flocculation of clay, which renders the fine soil more penetrable for water, air, and plant roots, and more manageable for implement work.

Second Plowing: After liming or, if the practice has been discontinued, after harrowing or subsoiling, the field receives its second plowing. This may be done with a reversible disc plow, or any implement suitable for local conditions.

Furrowing: This operation was formerly, and still is on some plantations, done with a mule-drawn double mould board plow. Now tractors are employed which draw one or more.

Five feet is the popular spacing for rows, as this gives ample room for cultivation between them, and the cane closes in over the kuakuas sufficiently to smother weeds. At upper elevations where more upright canes are planted, and growth is slower, the rows are spaced four or four and one-half feet, to more quickly help weed control by shading.

Subsoiling: As a last resort for opening up the soil, plows go to a depth of 4"-12" below the bottom of the furrow.

Planting: Variations of climatic conditions and soil call for different varieties of cane and different methods of planting.

Yellow Caledonia is still, by far, the most extensively cultivated cane on the lower elevations of Hawaii. According to a recent census the island had for a single crop 31,370 acres of Yellow Caledonia as compared to 7,873 acres of D 1135, its nearest competitor. Yellow Tip and Striped Tip have respectively 3,002 and 2,144 acres; the former is replacing the latter. H 109 is supplanting Yellow Caledonia on the irrigated lands of Paauhau and Honokaa. D 1135 is a cane of promise, as it is thought that by bud selection the smaller sticks can be eliminated in favor of a big stick strain.

Distance between seed pieces, their age (from 1 or 2-year cane) planting level or at an angle from butt to tip, entirely covered or not, is all a matter of local opinion, and conditions. In connection with bud selection work the writer took two seed pieces from 1-year-old cane, Caledonia, and of a possible 100% germination, 83.81% produced stools.

It is the practice in wet districts to incline the seed from butt to top, leaving the tip exposed, this prevents rotting before germination, and also prevents drying out, for if the lower eyes are 3" under the soil there is little danger from drought.

A practice is to plant the seed pieces butt to butt making a continuous row of cane, but the writer has found that under rather adverse conditions 24,306 stalks per acre were produced with 1' spacing, thus saving one-half of the seed.

RATOON CANE

Palipali: This operation, performed by the man with the hoe, is necessary if a large amount of trash is left on the field after harvesting, or if the stools are left high by careless cutting. The operation consists of cutting any high cane stumps, and hoeing the trash from the cane row into the kuakua. The trash acts as a mulch, suppressing many of the upright weeds and grasses until the cane can get a good start, but it has been the writer's observation that it is practically impossible to get rid of a growth of honohono which starts in the damp material and soon spreads everywhere. Without palipali (leaving the trash), you inevitably choose between a growth of honohono, or upright weeds and grasses. By burning after cutting, palipali is not necessary, and much honohono is done away with.

Off-barring Ratoons: Where level cultivation has been practiced, or with plant and first ratoons, this operation is not necessary. When the stool is older, however, it spreads outward, so it became a practice to cut away this new growth.

When performed, the operation is done with a 12" to 14" plow drawn along the outer edges of the stools, trimming them down to a square strip 10" to 18" broad and 4" to 8" deep; on a double disc plow, drawn by a tractor, cuts the stool perfectly, and a good share of soil is thrown into the kuakua, completely covering the weeds and trash.

Experiments indicate that off-barring reduces the yield of cane, but much can be said for the operation as a means of weed control. By covering, the trash is quickly rotted and the dirt thrown into the kuakua helps future implement work.

"An experiment at Hilo Sugar Company, comparing off-barring with the omission of the practice, resulted in 57 tons of cane per acre where off-barring was employed, against 59.4 tons where the practice was omitted. . . ."³

"*Off-barring, Plows, Hilling, Etc.*: In this test half of the plots were off-barrred, plowed, hilled, etc. In the other half no plows were used, weeds were controlled by surface cultivators, hoeing, etc. . . ."

"The results follow:

Treatment	No. of Plots	Tons Cane per Acre			Average Q. R.	Average Tons Sugar per Acre
		1919	1923			
No plows	9	56.2	55.4		7.99	6.98
Off-barring, plowing	9	55.6	51.7		8.02	6.70

. . . "The differences are not very great, and it would seem that on the whole, the matter resolves itself into the most efficient method of weed control with the least disturbance to the root system of the cane."⁴

"*Off-barring versus Not Off-barring*: In this test half of the plots were off-barrred and the other half were not. All other operations were uniform to all plots. The results follow:

Treatment	No. of Plots	Tons Cane per Acre			Average Q. R.	Average Tons Sugar per Acre
		1919	1921	1923		
No off-barring	9	59.4	62.0	53.0	8.04	7.23
Off-barring	9	57.1	60.7	49.3	8.28	6.73

"These results show loss in sugar from off-barring."⁴

Stool Shaving: After a crop of plant cane is cut, new buds sprout from the base of the old cane stalk and from the surface, and underground part, of the old stool. As years go on this new tillering broadens the stool and raises it above its former level until it is perched high above the kuakua, with a mass of rotten roots below it. Growth to the sides is restricted by cultivating and hoeing, but the upward growth is hardly checked.

In order to lengthen the life of the stool and forestall the expensive operations connected with planting, a stool shaver was devised to cut off the butts of the old stalks, just below the ground surface. The implements were mechanically perfect and supplanted the heavy work of the operation of the palipali, and also doing much in the way of weed control, but the stools could not stand the treatment and by experiment reduced yields were experienced.

"*Stubble Shaving, Onomea, 1921 Crop*: The crop cane here was Yellow Caledonia, third ratoons long. With the exception of the stubble shaving, all

plots received similar treatment. The yields from the different treatments are given below:

No stubble shaving.....	41.5 tons cane per acre
Stubble shaved	41.6 tons cane per acre

"It must be borne in mind when judging the results of stubble shaving that a substantial saving is made in subsequent hoeing where stubble shaving is practiced, so even if no gain in yield results, it may still be a profitable practice." ⁵

Stool Splitting: This operation of drawing a heavy implement fitted with a rolling coulter, to split the cane stools longitudinally through the middle and a subsoil plow to open up the area beneath the cane row was at first looked upon with great favor. It was thought that the opening of the stool would induce the buds on the lower part to mature, and the loosening of the soil beneath the row, a section of which with old ratoons was not disturbed at all, would create a greater root growth. The device was improved so that stool splitting, subsoiling, and off-barring could all be done in one operation.

At Hilo Sugar Co.—"Stool splitting and off-barring as compared to off-barring alone shows a loss of 2.84 tons of cane per acre. Stool splitting alone as compared to off-barring alone shows a difference of 3.30 tons of cane in favor of the off-barred plots." ⁶

Cultivation: The Planet Jr. and Horner cultivators are the most popular implements for weed destruction between the cane rows. The former is usually passed three or four times along the kuakua, thus breaking down the weeds, uprooting them and scratching the soil to a depth of 2 or 3 inches. If burning has not been done after harvesting, the Planet Jr. insures more rapid decomposing of the trash by turning it over and mixing it with weeds and dirt.

After hoeing the cane rows, (hand work) the Horner Cultivator, or hapai harrow as it is locally called, drags the weeds into piles and covers them with earth. These piles, by the time the next hoeing is necessary, are quite rotted away. The Planet Jr. breaks down and spreads this decayed material.

The operations of cultivating, hoeing and harrowing, are repeated as often as conditions demand, to keep the fields free of weeds.

The Value of Weed Control: "In an experiment at Kilauea, weed control increased the cane yields by 7 or 8 tons of cane per acre, while fertilizing increased the yields about 9 tons of cane per acre. Clean culture with no fertilizing produced about as much cane as fertilizing without weed control." ⁷

"Cultivation—Regular Practice vs. Weed Control Only: A comparison was made between regular plantation practice off-barring, middle breaking, hilling, etc., with cultivation for weed control only, by means of hoeing, small cultivators, etc.

"The yields of the two sets of plots were identical as given below:

	Yield per Acre		
	Cane	Q. R.	Sugar
Regular practice	56.2	7.03	7.99
Cultivation for weed control only.....	55.6	6.91	8.04''s

"A Cultivation Experiment at Hakalau: In this experiment a gain of almost a ton of sugar per acre was obtained from the plots receiving no animal cultiva-

tion, weed control being done by hoeing. Mr. Verret also reports that 'plots which were not off-barred produced half a ton of sugar more than those which were.' " "

Hamakua Mill Company: "No appreciable differences in yield from the various treatments were found, and Mr. Verret advocates that the cheapest method be followed with special consideration to the saving in man-days in times of labor shortage.¹⁰

Hakalau experiments turned out likewise.¹¹

Hilling Up: This operation, formerly practiced on all plantations, on all crops, is now curtailed. The operation comprises the loosening of the soil in the kuakua with 8" or disc plows, at the time the cane tops from adjoining rows begin to meet. The loosened earth with any weeds or trash was then thrown on to the stools with celery hillers, wedge-shaped "snow" plows, or by handwork with the hoe.

Claims made for this operation were: loosening of the earth, weed destruction, better drainage (especially for upland fields), better support for cane stalks, and covering fertilizer.

To quote James Webster, manager Pepeekeo Sugar Company, "In hilling up, this root cutting is even more detrimental to the root and plant growth, as by that time the roots are all across the kuakua or space between rows and cutting them is depriving the plant of its feeding organs. Not only that, but the good soil is hilled against the cane, leaving a V-shaped ditch between the rows, the bottom of which is in the subsoil and devoid of anything in the way of plant food. It offers also a splendid start for erosion in heavy rainfall. The area to feed upon is reduced, and, while it may be said that the soil is still there, its value is greatly reduced by the fact that a considerable depth of the hill's surface is rendered inert by the way it is exposed to the elements."¹²

Hilo Sugar Co. Hilling: "In this test half of the plots was hilled, and the other half was not, otherwise all treatments to all plots were the same. The results follow:

Treatment	No. of Plots	Tons Cane per Acre			Average Q. R.	Average Tons Sugar per Acre
		2nd Rat. 1919	3rd Rat. 1921	4th Rat. 1923		
Not hilled	10	60.9	68.4	51.2	7.75	7.77
Hilled	10	57.0	66.8	51.9	7.88	7.44

"The average of 3 crops, carried to fourth ratoons, is distinctly in favor of not hilling."¹³

Stripping: The operation of ridding the cane of its dead leaves has received much discussion on the part of the Sugar Planters of Hawaii. Experiments have conclusively proven that the operation is an expensive one but well stripped cane is good to look at, and the tendency is to divert gangs to this operation when urgent work is not at hand.

The subject is quite ably handled by Mr. C. F. Eckart at the Planters' meetings of 1911 and 1914, in which tests on an extensive scale were mentioned wherein an actual loss of labor and dollars was brought about.

Weed Control by Paper Mulching: Cultivation on Olaa Sugar Co.'s lands is mostly for weed control. The nature of the soil, in the lower section, quantities of rocks, and in the upper fields, the heavy rainfall and shallow top soil, forbids the use of implements for covering the dense growth of weeds which are stimulated by excessive rainfall.

Because of these conditions adverse to implement work, the practice of mulching the cane rows with a sheet of bagasse paper saturated with asphalt and oil has been adopted. After harvesting the cane, trash and weeds are palpalied into the areas between the cane rows. A strip of paper 30" to 35" wide is superimposed directly over the cane row and held down with any available material (cane trash, stones, dead cane stalks, etc.). In a few days the cane shoots begin to pierce the paper and develop normally. Because the cane row is uneven, some of the shoots expand before they touch the paper. They continue to grow in darkness and force the paper to "tent". About three weeks after papering, these "tents" are cut longitudinally along their ridges, thus allowing these etiolated shoots to mature.

The trash which has been hoed into the kuakuas acts as a mulch against upright weeds and grasses, so the principle weed we have to contend with is the honohono which grows quite luxuriantly, first in the kuakua then, if it is not checked, spreads over the paper.

A modification of the Planet Jr. cultivator, and the hoe is the only means of combating the weeds in the rainy season. The Horner harrow is used but not with the effectiveness obtained on the Hilo Coast plantations.

Weed Control by Spraying: When good weather prevails, spraying with arsenite of soda is an effective means of checking the honohono. A stock solution of arsenite of soda is made by boiling in water 2 lbs. of white arsenic with 0.42 lb. of caustic soda until the solution becomes clear, this is made up to 1 gallon with water. To make a spraying solution for honohono or other succulent growth, dilute this to make 25 gallons. For grasses such as *Panicum* dilute to 10 gallons. The addition of soap at the rate of 1 lb. (any cheap kind) to 100 gallons of spraying solution increases the effectiveness of this spray by acting as a spreader, causing the solution to stick to the leaf surface rather than form drops and roll off. The solution is effective only on the surface which it touches. Even after thorough saturation the effect of the poison on the soil is only temporary. The spray is applied from knapsack sprayers, the sled sprayer described in the *Planters' Record*, Vol. X, or by a combination of a sled, 50-gallon barrel, and a hand pump equipped with 3-50' lengths of hose. Meyer's No. 1290 Frembro nozzle is the favorite. Because of the demand for arsenic in fighting the boll weevil in the South, the price is rising to a prohibitive figure.

As the laborer, who sets out to hoe the row himself, misses some weeds, so have I, in writing this article missed some of the operations that might have been incorporated to make it a complete report, so I would be glad of any suggestions or additions. I hope to visit the plantations along the Hilo coast before the meeting in October, and may then have some information and pictures to add.

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12 Proceedings of the Forty-Second Annual Meeting of the Hawaiian Sugar Planters' Association.

A Questionnaire on Seedling Propagation*

BY H. F. HADFIELD †

The following are replies to a questionnaire on cane varieties and seedlings sent out by the Committee on Hawaiian Cane Varieties and Seedlings of the Hawaiian Sugar Technologists:

In the replies under general remarks:

"H. P. Agee, Director of the Experiment Station, cautions us as follows: 'When we select seedlings and find a growing inclination to favor one type over another it is well to carry with us a mental picture of the fact that among the important commercial cane varieties of the world we have such variations in form as occur between Uba, Yellow Caledonia, H 109, Badila, Yellow Tip and D 1135. It will be hard to find in your seedling fields wider variations in type than these six canes present. When all is said there is no criterion to take the place of sugar per acre. For this, we need in Hawaii a cane which will hold over for several months without deteriorating too much, one that will ratoon well, one that will not tassel too freely under average conditions. When it does tassel it must have a capacity to send out lalas from the upper joints to maintain the life of the stalk. Several otherwise promising seedlings have gone into the discard because of the inability to lala and preserve the stalk from rotting back from the top.'"

W. P. Alexander of Ewa, brings out the following points: "In observing seedling growth and in handling the selection of varieties, off and on, for a period of almost eight years, I have found that it is not easy to lay down definite rules for selections because conditions on the Islands vary so much.

"Plant breeding work in other crops is simpler and more rapid than in sugar cane. Sugar cane usually takes 20 months to mature, while most other crops have at least one crop a year. Varietal work in sugar cane requires much patience and results are slow and perhaps at times discouraging.

* Presented at the Second Annual Meeting of the Association of Hawaiian Sugar Technologists, Honolulu, October 22, 1923.

† Chairman of the Committee on Hawaiian Cane Varieties and Seedlings.

"To get best results one person must be engaged in the selecting of cane seedlings continuously over a period of many years, not less than six, if possible. He must have a personal contact with the varieties. Weekly inspection of the seedling areas is a great help.

"Observation notes made at least every month are essential if the growth habits of the seedling canes are to be really studied. The finding of a cane to meet particular conditions means that the selectionist must understand what these specific conditions are. It would be a mistake for one to select an H 109 type cane for mauka lands on Hawaii, just as much as it would be to pick a Tip cane for the lowlands of Oahu.

"Progress in selection of varieties depends upon constant observation of the canes by an agriculturist who has an intense interest in his project. In India, where great strides have been made in cane breeding, one man handles only 300 varieties, and devotes his entire time to these alone."

H. E. Starratt of Olaa says: "You have a very interesting topic to handle, and to my mind the subject of varieties and seedlings is the most important in the whole sugar industry of these Islands.

"As no one question asks us point blank how we consider this subject in relation to other problems of plantation and mill, before answering, I should like to bring out a few points on this matter.

"Foremost of all problems is that of procuring the right variety and seedling for the climate or conditions under which you must grow cane. Before a cane is introduced to a locality on a commercial scale, extensive tests should be carried on with it to determine its yielding and ratooning qualities, the sucrose content, susceptibility to disease and insect pests. It must also have good milling qualities, so that the sugar may be extracted, and a sufficient amount of bagasse formed to help keep the fires burning. What plantation has had a sadder experience with varieties than Olaa Sugar Company? Referring to the managers' reports such statements as these are found:

Crop 1906. We are having the same experience with the Lahaina cane which all the other plantations on this Island have had, but we are working out this variety as fast as possible.

We have 3,000 acres available to plant for this crop. This is a large acreage to plant in one season, but we have to use every effort to get as much Yellow Caledonia in as possible.

Crop 1907. Over 1,000 acres of wretchedly poor Lahaina ratoons were harvested which yielded about three-fourths of a ton of sugar per acre.

Crop 1909. There were also included in this crop 500 acres of Rose Bamboo, the last of this variety, which has proved unsuitable for conditions at Olaa and which no longer will be planted.

We planted (1911) 170 acres of D 1135 at Mountain View and 165 acres at Nine Miles.

Crop 1921. Of the plant area 122 acres is H 227.

This variety has shown up very well on our Mountain View section, and we intend spreading it as fast as we can.

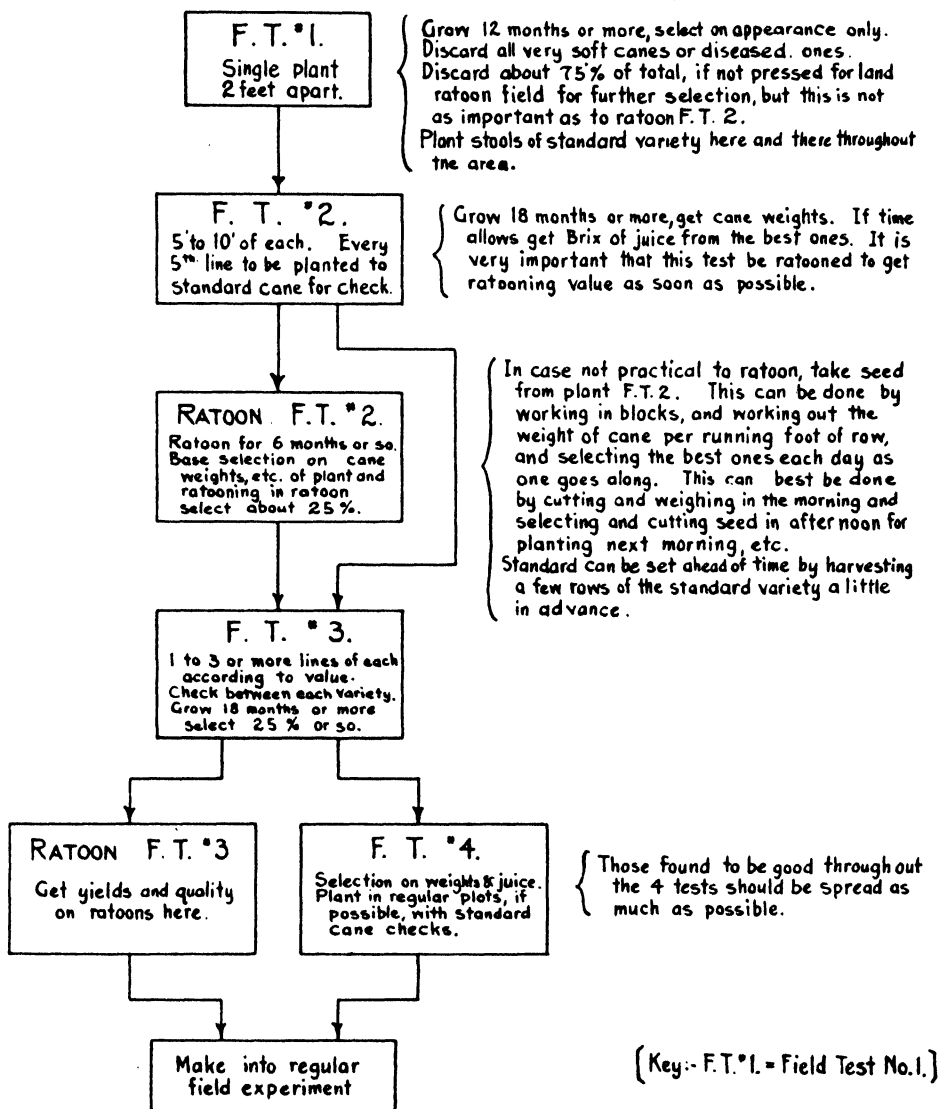
It seems to be adapted to the climatic conditions up there, and is also much more resistant to leafhopper attacks, than either D 1135 or Yellow Caledonia.

Crop 1923. This year we will have abandoned 157 acres of H 227, as it does not ratoon.

J. A. Verret, Agriculturist, H. S. P. A. Experiment Station, offers for discussion the following, "Outline of Seedling Selection" (see page 55), and remarks:

"The outline as given is not intended to be final but as a matter for discussion. There is some difference of opinion among cane breeders as to the best methods of procedure and it is very desirable to have a full discussion on this.

OUTLINE OF SEEDLING SELECTION



Grow 12 months or more, select on appearance only. Discard all very soft canes or diseased ones. Discard about 75% of total, if not pressed for land ratoon field for further selection, but this is not as important as to ratoon F. T. 2. Plant stools of standard variety here and there throughout the area.

Grow 18 months or more, get cane weights. If time allows get Brix of juice from the best ones. It is very important that this test be ratooned to get ratooning value as soon as possible.

In case not practical to ratoon, take seed from plant F.T.2. This can be done by working in blocks, and working out the weight of cane per running foot of row, and selecting the best ones each day as one goes along. This can best be done by cutting and weighing in the morning and selecting and cutting seed in afternoon for planting next morning, etc. Standard can be set ahead of time by harvesting a few rows of the standard variety a little in advance.

Those found to be good throughout the 4 tests should be spread as much as possible.

In planting, use a '3-eye' seed piece from which two eyes are gouged out. Let the best eye be kept and cut the seed so that the best eye is in the middle. Plant one eye per foot. In wireworm country, or where general conditions are poor, use twice the amount given above. Plant 2 or 3 extra seed per each 10 feet to replace any misses. When the stand is full, destroy extra shoots, leaving one per running foot. Use good seed, and of the kind which experience has shown is best in that district. The percent to be selected or discarded as indicated above is more or less nominal and will vary within very large limits depending upon conditions.

J.A.V. 57

"A very important point in seedling work, which, in the earlier stages of the work, through lack of sufficient experience, was, perhaps, not stressed enough, is the importance of a careful selection of the parents, bearing in mind the localities in which the seedlings are to grow. For instance, it is obvious that when trying to get a cane adapted to mauka sections, in soils where root-rot is prevalent, the

best parents would not be Lahaina and H 109, but rather the Tips, D 1135, Uba and when available, the recently introduced Java seedlings. In using the Tips as our parent one should bear in mind that these canes are very susceptible to mosaic so the other parent should be from the more mosaic-resistant canes such as Uba, Badila or D 1135.

"In getting crosses for general field work we do not believe it is necessary to go to the trouble of using the cage methods. Our data, based on the handling of many thousand tassels, go to show that most seedlings are the results of crosses in the field. This is shown by the fact that tassels taken from the center of large fields where only one variety is growing, always give very poor germinations as compared to tassels from the edges of these same fields with other varieties adjoining.

"When trying for Yellow Tip and D 1135 crosses, take D 1135 tassels where Yellow Tip adjoins the area to windward, and Yellow Tip tassels with D 1135 to windward. A method used by the Station is to plant the two parent canes mixed in the line, or to plant a line of each, and then to collect all tassels."

Question 1. What cane varieties do you grow on your plantation?

W. P. Alexander, Ewa Plantation: H 109 is the standard variety. Areas are planted to Badila, Yellow Caledonia, H 456, H 468, H 471, H 472, H 5919, H 5946, H 5953, H 5986, Ewa Varieties Nos. 177, 383, 386, 388, 509, 519, 720 and 722. Plot tests of many other varieties including Ewa seedlings Nos. 700, 362, 225, 712, 371, 731, 405, 378, 740, 380 and H. S. P. A. seedlings of 1917 and 1918 propagation.

C. F. Poole, Hawaiian Sugar and McBryde: (a) Makaweli. H 109, D 1135, Y. C., H 146 and Kauai seedlings from 1918 to 1922.

(b) McBryde. H 109, D 1135, Y. C., H 456, H 468, H 471, H 472, a small amount of Yellow Tip, and Kauai seedlings from 1918 to 1920.

A. T. Spalding, Honouliuli: We grow Yellow Caledonia extensively, also D 1135, D 117, H 456, H 109, H 227, H 72, Badila, Striped Mexican, Yellow Tip, Rose Bamboo, and a few others to a small extent. We are bringing along about a hundred unnamed Honouliuli seedlings with good success. Sufficient time has not yet elapsed to segregate the very best.

H. E. Starratt, Olaa: 1. Varieties grown here are Yellow Caledonia, on lower lands at Olaa, Kapoho and Pahoa. D 1135 above elevations of 1,000 feet, some on lower lands which is usually short ratooned.

We are investigating H 400 seedlings, especially H 456 for elevation of 1,500 to 1,700 feet, also 1917 Oahu propagations by the H. S. P. A.

Same seedlings for mill region with Badila and Badila seedlings (the last named just planted).

Three seedlings started in 1917.

The "Lyman" seedling started from H 109, is doing well in the hot dry district of Kapoho, and the other two, Olaa 1 and 2, from H 146, are promising for the Olaa district.

John C. Thompson, Hawaiian Agricultural Company: The following varieties are grown on this plantation and in the order of their importance:

Yellow Caledonia,
D 1135,
Yellow Bamboo,
Striped Mexican,
White Bamboo,
Rose Bamboo,
H 72,
D 117.

The following varieties and seedlings are found, having been grown in varietal plots for a number of crops:

Yellow Tip,
Badila,
Black Tanna,
Caledonia Ribbon,
B 306,
D 116.

H 25	H 240	H 5902	H 5953
H 27	289	5904	5955
33	291	5908	5962
45	304	5909	5964
51	311	5912	5965
65	333	5917	5971
68	409	5919	5972
69	411	5922	5973
87	416	5923	5974
109	425	5926	5978
118	427	5927	5986
122	431	5929	5987
126	456	5930	5988
130	458	5935	5994
135	457	5946	5995
145	460	5949	
151	462		
197	463		
202	464		
227	465		
	466		

Stafford Austin, Hilo Sugar Company: We have an assorted number of cane varieties on this plantation, among them are: Caledonia, D 1135, Striped Tip, Yellow Tip, Badila, H 227, 309, 109, and a good many H 109 and Lahaina seedlings that are under observation.

Question 2. What cane varieties or seedlings do you consider best for mauka and makai lands in your district?. Please state your reasons. Replies were received and are given below:

W. P. Alexander: H 109 grows well from 0 to 200 feet, our highest elevation.

Charles F. Poole: (a) Makaweli, makai, H 109; mauka, D 1135.

(b) McBryde, makai, H 109 and Caledonia; mauka, Caledonia and D 1135. However, on either plantation we have not real mauka lands, and H 109 seems to do well anywhere if we can get a dependable water supply.

J. S. B. Pratt, Jr., Associate Agriculturist, H. S. P. A. Experiment Station: For varieties for mauka lands, I would work with Tip and D 1135 crosses, for those seedlings we have already tried show the Tip character of being a cane to close-in quickly. Uba and Badila canes may be good canes for mauka land seedlings. Instead of working with untried seedlings as parents, I figure that our best chances for makai land canes are with seedlings of H 109 and Lahaina parentage. The most promising seedlings to date have come from these varieties.

A. T. Spalding: On the mauka lands of Honomu we have not had much success with any variety. D 1135 is certainly the most promising. We have had several good crops of D 117 off certain areas, but this cane does not ratoon well. Yellow Caledonia is fair. Yellow Tip shows up better a little further mauka on drier lands. Yellow Tip is my idea of a cane between 800 and 1,000 feet elevation. On the makai lands we have tried several varieties including H 109. This cane gives good tonnage per acre, but being a recumbent cane the grass is hard to control. Y. C. is our mainstay yet, although I am sure it is losing its ratooning qualities and in time will "peter out" like Lahaina.

H. E. Starratt: Above elevation of 1,000 feet the D 1135 has given very satisfactory crops, and ratoons very well.

Yellow Caledonia is used on the lower lands for the same reason.

J. C. Thompson: Mauka and Makai Land Canes. Before discussing the merits and demerits of our best varieties and seedlings, it would be best if our conditions here were described. In the first place, the lack of water on this plantation makes it impossible to take the crops off at the right time, causing a loss of sugar, more so if the variety in question cannot stand over. The cold mauka conditions are such that it takes fully two and one-half years to harvest a crop on those lands, for during the four months from December to April little or no growth takes place. The lack of rainfall on the makai lands together with the shallowness of the soils of certain fields is another aspect to be considered in selecting our varieties.

D 1135 has proven the best variety for our mauka lands. It germinates well if good seed is used, grows fast and tillers out better than most varieties. Its ratooning ability is superior to that of most varieties. It is very resistant to most diseases, being more resistant to Yellow Stripe and Pahala Blight than our other varieties. Its upright growth and its ability to shade in well are important factors in the control of weeds in our mauka fields. The yields of this variety are excellent, 550 acres at an elevation between 2,200 and 2,800 feet yielding 68 tons cane to an acre last year.

Yellow Bamboo, our second best mauka cane, is being replaced due to its susceptibility to diseases and leafhopper. It is severely attacked by a fungus disease which breaks down the leaf tissues in spots. Resistant strains of this variety would make an ideal cane for the mauka lands, on account of its ability to stand over better than other varieties.

Rose Bamboo, White Bamboo and Striped Mexican although found growing on large areas in our mauka fields are not what one may call good mauka canes.

H 72 would be an ideal seedling to propagate on larger areas, if it were not for its inability to stand over. It grows well, matures quickly, but goes back if allowed to stand over two years. Its ratooning ability is superior to that of D 1135. If it were possible to harvest our fields on time, H 72 would be an ideal cane.

For the makai lands, Yellow Caledonia has proven the old reliable. It survives the severe drought more easily than any other variety. The shallow soil in certain fields together with the prevailing Pahala blight makes it impossible to replace the hardy Yellow Caledonia with less hardy varieties. Seedlings such as H 227, H 291, H 416, H 451, H 466 and H 416, which have done well in some fields, are not as good as Yellow Caledonia.

The H 400 seedlings are, on the whole, undesirable on account of their inability to shade in and suppress weeds. In fact quite a few of the other seedlings have been discarded for this reason. In a varietal test recently harvested H 416 and H 466 showed up best, the former yielding at the rate of 75.90 tons of cane to an acre and the latter 79.22 tons.

Of the H 59 seedlings H 5965 has proved the best. H 5965 grows very fast, being about the fastest growing seedling I've noticed. It does well up on the mauka fields and also on the lower or makai irrigated fields. Whether it will do well on the makai unirrigated and dry section remains to be seen. This variety is being spread.

H 5972, H 5971 and H 5949 also look well although not anywhere near as good as H 5965.

J. A. Verret: H 109 is not at its best above about 400 feet. Also, it is very susceptible to eye-spot when planted in localities subject to wet winters and no great wind movements. One should therefore be careful in planting H 109 in fields subject to heavy dews and protected from wind. Caledonia begins to be high when about 800 to 1,000 feet elevation. Above that up to about 1,400 to 1,500 feet D 1135 does well. Above this the tips are generally more suitable. These figures are general, only, and vary to some extent in different places. In parts of Hamakua, for instance, D 1135 is better than Caledonia at lower elevations than 800 feet. On the other hand, some of the best D 1135 on the islands are in Pahala at 2,000 feet and over.

Mr. Austin: We consider Caledonia the best cane for our makai lands. The reasons are as follows:

1. Sturdy growth, not too fast to mature.
2. Does not tassel very readily, even at low levels.
3. Hard outer shell, preventing it being eaten by rats.
4. Covers in early, decreasing the cost of cultivation.
5. Does not rot out early, even with big rains.
6. Seems to be our easiest to cultivate in this rainy district.
7. Ratoons well.

We consider D 1135 our best mauka cane. The reasons are as follows:

1. Abundant growth.
2. Good juices.
3. Ratoons exceptionally well.
4. Does not tassel early at high elevations.
5. Ratoon crop very cheap to cultivate.
6. Stands the cold and rainy weather very well.

Question 3. Do you believe in every plantation setting aside an experiment plot for the purpose of selecting seedlings and varieties to suit their own conditions?

H. P. Agee: Any plantation would, I think, profit in setting aside a suitable area for testing seedlings and other cane varieties.

W. P. Alexander: Yes.

Charles F. Poole: Yes.

J. S. B. Pratt, Jr.: Every plantation should have areas to try out seedlings. Our best chances come in working with quantities, and being very rigid in our selection. Canes must be tried out under all conditions on a plantation before being thrown out.

A. T. Spalding: An experiment plot on a plantation should not only be set aside at one elevation, but at several, in order to determine the variety suited to the environmental conditions.

H. E. Starratt: Every plantation should set aside a plot for seedling investigation, and the plot should be reserved for the seedlings until they prove themselves a failure or a success.

Plowing up areas planted to seedlings which are still under investigation on other parts of the plantation is throwing away a valuable score of information.

John C. Thompson: I believe that every plantation, large and small, should set aside experiment plots for the purpose of selecting seedlings and varieties to suit their own conditions. The plantation that carries on seedling work on a large scale will no doubt be most successful.

J. A. Verret: Some of the best of the more recent seedlings we have were started on the plantations. The Wailuku, Makaweli, Kohala and Ewa seedlings are instances, also those of Honomu and Hilo Sugar Company.

Mr. Austin: I thoroughly believe in every plantation setting aside an experimental plot, for the purpose of selections and varieties of seedlings suitable for its own purpose.

Question 4. What, in your opinion, constitutes an ideal seedling cane, supposing you were to set out to grow one?

H. P. Agee: The ideal seedling cane is the one that takes the maximum advantage of the production factors of its environment. Under adverse conditions, where weed control is the important consideration, we need hardy canes which can be handled at a low expense per acre and make a sufficient sugar yield to make that culture profitable. Under good conditions, we want canes capable of high sugar productions so that the heavy expenses of fertilization and irrigation will be offset by heavy yields.

W. P. Alexander: A cane that (a) gives tonnage of cane with high sucrose content, (b) will mature early in the season and yet not "go back" before August or September, (c) will be resistant to root-rot, eye-spot disease and other cane diseases.

Charles F. Poole: An ideal seedling cane for a plantation with high temperature and a good water supply is one that ratoons well, has broad leaves, large heavy stalks, with long joints and strong eyes, and a sound fairly tough rind. However, the real test is the weights and quality of the juices, especially in the ratoons. For a plantation like McBryde, where the water supply is not constant, and the temperature varies, my tendency would be to favor a narrower leaf, but I should not allow any preferences to interfere with the weights and general vigor of the ratoons.

J. S. B. Pratt, Jr.: An ideal seedling cane must first have good agricultural characters, depending upon the plantation. It must be a good ratooner, for we raise ratoons in Hawaii and not plant cane. After canes are selected on their agricultural characters, sucrose content can be the basis for selection.

A. T. Spalding: My idea of a seedling cane is one of the 'Y. C. type, not necessarily the same color, but possessing the inherent qualities.

H. E. Starratt: An ideal cane must be a high yielder, a good ratooner, have high sucrose, good milling qualities, and be able to resist insect pests and diseases.

J. C. Thompson: From the standpoint of a field man, a seedling with the following characteristics is desired:

1. Good crop.
2. Erect growth.
3. High vitality.
4. Non-liability to disease.
5. Good stooling ability.
6. Good shading ability.
7. Early maturity.
8. Ability to stand over.
9. Good ratooning ability.
10. Very resistant to drought.

The sucrose yield, the percent bagasse, and the percent juice are also to be considered in the final selection of the seedling.

J. A. Verret: The highest average producer at the lowest cost. I know of no way to determine this except by trial.

Mr. Austin: If I were setting out to select an ideal seedling, I would look for the following qualities:

1. Juice quality.
2. Sturdy growth.
3. Quality to withstand disease.
4. Plant and ratoon quality.
5. Covering in quality to afford cheap cultivation.
6. Quality to withstand wet weather.
7. Size of stick.
8. Number of sticks.
9. An ideal seedling should be half way between the erect and recumbent.

Question 5. In germinating seed from arrows, do you find that the quick and slow-growing germinations retain these qualities until harvesting time?

H. P. Agee: We have some indications that strong varieties will show their vigor at a very early age, but we do not have sufficient information as yet, to justify a selection or elimination when the plants are in their infancy. The issue is clouded by the fact that young seedlings may be injured in transplanting and thus show to disadvantage.

Charles F. Poole: There would seem to be this tendency, but there are many instances of exceptions.

J. S. B. Pratt, Jr.: Not enough data to decide, but I have always likened seedling work to a horse race; the horse that is ahead at the first lap is not always the one to finish first.

J. A. Verret: There is some evidence that elimination to the extent of perhaps 50% can be made at the age of three months or so, when transplanting from pots to field. In doing this you run some chance of discarding good canes, but you can handle twice the number in pots and this should much more than make up the possible loss.

Mr. Austin: I do not find that all seedlings retain these qualities until harvesting time.

Question 6. How many selections do you think should decide the qualities of a seedling?

H. P. Agee: We cannot specify a definite number of selections. Our so-called selection is in fact a process of eliminating those canes which show little promise. The severity of this elimination depends upon many factors. The number of seedlings you have in proportion to the amount of land available for this work, and the number of seedlings you propose to start the following year, are important considerations.

W. P. Alexander: It is a process of elimination about as follows: First selection by observation can reject at least 60% of the original plant stools as not worth planting out. Ratoons should be grown and another selection made including those first discarded. Second selection of "line tests" by observation or weighing the cane, can throw out about 50% again. Ratoons are carried on, however. This leaves about 20% of the original canes in the third selection in plots. Yields per acre and juice analysis are needed. Only those that compare favorably with the standard canes should be cut and planted out again. The number may vary but it will be from 5 to 10%.

Charles F. Poole: At least five field tests, with special emphasis on the ratoon plots.

J. S. B. Pratt, Jr.: The best seedlings must be tried out on field scale before all qualities can be determined. Possibly 75% can be thrown out the first selection, though it is argued that a cane does differently when grown from a seed-piece than from a small seed. However, unless a rigid selection is made, one cannot work with quantities with the same time, money and space.

A. T. Spalding: This is rather a big question. From my experience I could not give any definite conclusion. I think they should be given at least three selec-

tions. On the other hand a cane not promising well mauka might do well on makai lands or vice versa. A longer period of selection might be necessary. This is something deserving of careful study on the part of seed selectionists and field men.

H. E. Starratt: If you have room and can handle large numbers of seedlings, be slow to throw one away until it can be tested for yield and sugar content. If you are restricted for area, leave the seedlings in the original box until, by the law of the survival of the fittest, the number is reduced to what can be properly handled.

John C. Thompson: At least three selections, not including the first planting out of the seedling, should be carried out to decide the qualities of the seedling. This will enable us to judge the seedlings according to the following diagram:

1923 seedling	1924 ratoon	1925 ratoon	1926 ratoon
1924 plant	1925 "	1926 "	
1925 "	1926 "		
1926 "			

Of course this could be carried out only with the best and most promising seedlings, for the poorer seedlings would be discarded after the first and second years.

Mr. Austin: A seedling should run until the second ratoon before a decision is made as to whether it should be kept or thrown out.

Question 7. Would you select a seedling by its ratooning qualities, or by planting it every crop?

H. P. Agce: Our commercial varieties must be satisfactory ratooners. It would therefore seem at first thought that we would be justified in letting our seedling plots ratoon several times and selecting those which make a good showing as second, third or fourth ratoons. In practice there is an objection to this in that we would be carrying very small areas of a large number of canes, when by replanting them we could have larger amounts of a fewer number.

W. P. Alexander: Ratooning qualities are usually the best criterion of a cane's vigor. A plant crop of a seedling may be deceiving as to its true value. I would like a test on both plant and ratoon. Not on one crop alone.

Charles F. Poole: By ratoons.

J. S. B. Pratt, Jr.: A cane's merits must be decided by its ratooning abilities, but until enough material is obtained a yearly cutting will enable us to more quickly judge the ratooning abilities.

A. T. Spalding: By its ratooning qualities. We could not afford to plow up and plant cane every crop unless sugar stayed at war time prices.

H. E. Starratt: Under our conditions, the ratooning qualities of a cane are extremely important, but for several years the promising seedlings should be out at least over a year (more if possible) in order to spread them to a larger test area.

John C. Thompson: A seedling should be selected by its ratooning qualities, although its ability to germinate well in plant cane is quite essential.

J. A. Verret: Good ratooning is essential. No cane should be recommended unless it ratoons well. All plantings after the first selection should be ratooned. We do not believe it advisable to ratoon the first planting from pots, however, on account of the large number of inferior plants.

Mr. Austin: I should select a seedling by its ratoon qualities.

Question 8. How old should a seedling be, when final selection is made?

H. P. Agee: The question is not clear. If you mean what should be the age of a seedling in months when the selection work is done I would state that after two years' growth you can tell more about the ability of a cane to hold over without rotting, but we also encounter the difficulty of getting a nice lot of fresh seed, particularly if the canes have tasselled freely. For this reason, work in younger cane is often justified notwithstanding the disadvantage on the other score.

W. P. Alexander: The age at which a seedling should be selected depends ultimately on whether one is looking for a cane maturing in one year or at 20 months. One reason so many mediocre canes have been selected for two-year cropping is that they are chosen on the record of one season's growth. A large majority of seedlings seem to be rapid growers for the first ten months and then during the second season either stand still or actually die out.

There is, however, a practical side to the technique of selecting cane. First, it is necessary to eliminate the worthless canes as soon as possible. Good land, water, and fertilizer, with the necessary labor involved in cultivation of cane cannot be wasted on a lot of scrubs. We know that at least 75% of our original seedling plants must be discarded sooner or later. Second, if the selection is to be based upon observation, a recumbent two-year old cane is so hidden with trash and the stalks of different canes are so mixed up that it is almost impossible to judge its quality. When the cane weights are obtained this difficulty is not so great.

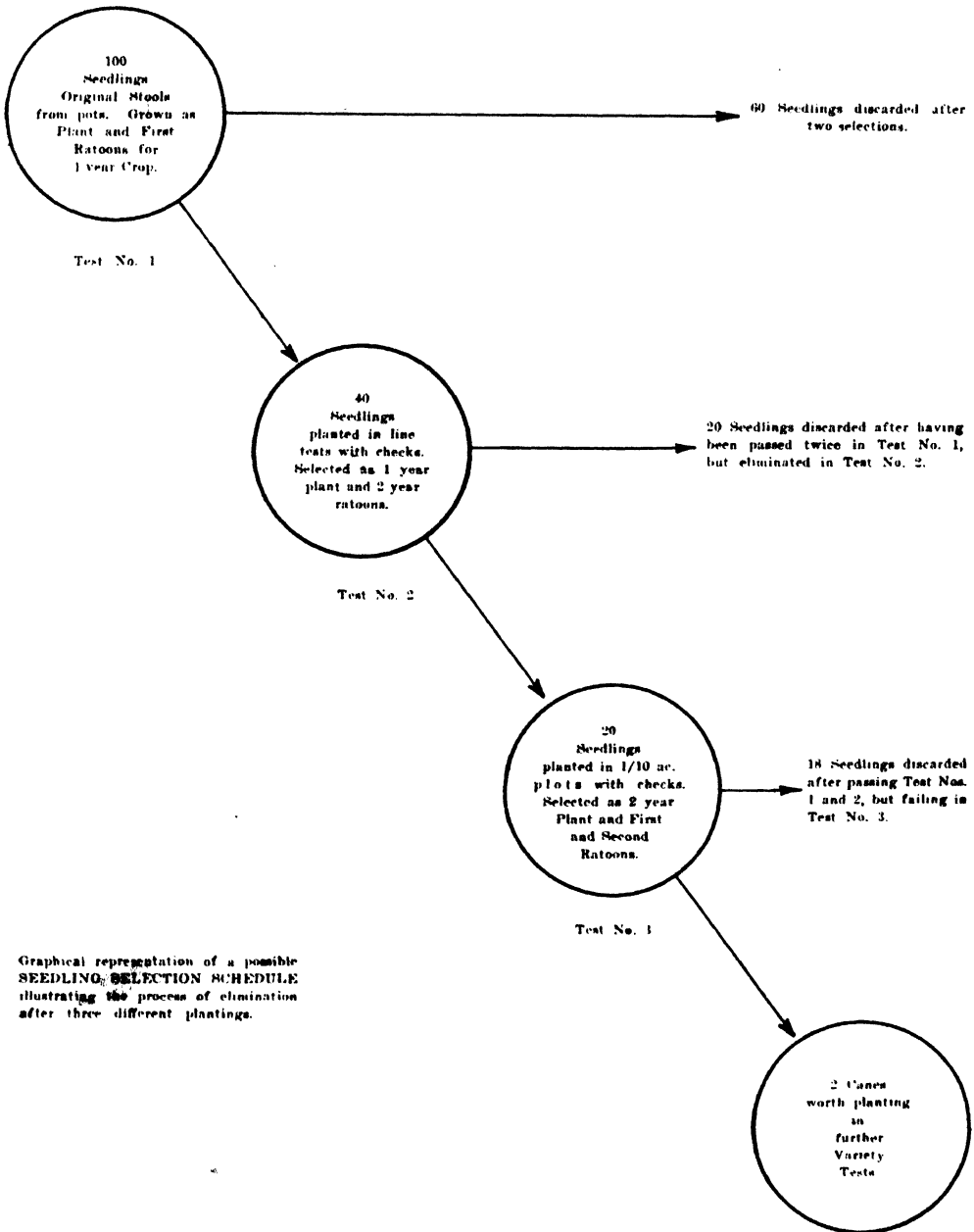
A plan of selection which calls for the first two selections on one-year cane material is a compromise which is O. K., provided eliminations are leniently made. However, by the third year a two-year test should be started, and all the selected ratoons of the first and second plantings should be allowed to ratoon for two years, unless cut for seed on account of the results secured from the third and fourth tests.

Charles F. Poole: The best studies can be made from at ten to fourteen months, while the stalks are still upright, and at this time seed for new field tests is best; but at least one crop, around the second or third field test, should be allowed to run to 20 or 22 months to give weight and juice data, and the following field test could be made from the ratoon.

J. S. B. Pratt, Jr.: I would strive to get seedlings to mature in 18 months.

A. T. Spalding: From eighteen months to two years unless you are an exponent of the two crops in three years theory, then I should say from twelve to sixteen months.

H. E. Starratt: Ten years is a necessary period for a seedling to be observed and tested, before it becomes of commercial importance.



Graphical representation of a possible
SEEDLING SELECTION SCHEDULE
illustrating the process of elimination
after three different plantings.

H 109, started in 1905, began to show up at Ewa in 1913, and only within the last few years, has it jumped into its prominence.

H 227, ten years ago was showing indications of importance, it is now condemned.

John C. Thompson: A seedling should be mature when the final selection is made, even though it may take only eighteen months for the cane to mature.

J. A. Verrett: The age of a seedling cane when selected (after the first selection) should be as nearly as possible, the age of your cane at harvest. There is some drawback to this in that old tasseled cane will give much less good seed. But one should carefully guard against selecting cane too young. Many canes are splendid at 12 months and mostly dead at 24. That type of cane is not desirable.

Mr. Austin: A seedling should be 18 months on makai lands, and 22 months on mauka lands before final selection.

Question 9. Which do you prefer, a seedling with a large number of thin sticks, or one with a small number of large sticks, supposing their sugar content the same?

H. P. Agce: There is too much prejudice against canes with thin sticks. We are apt to find hardy varieties among such canes and one would do well to bear this in mind in conducting seedling work.

W. P. Alexander: Providing sugar yield and also sugar content is the same, I prefer a cane with fewer but larger stalks. The whole process of cultivation, harvesting and milling is more difficult with a small stalk cane. If a better yield of sugar per acre is obtained with a small stalk cane, both in plant and ratoons, we should not be prejudiced against it.

Charles F. Poole: Would fight shy of either extreme, seeking a large number of large stalks, but if compelled to make such a choice would be inclined to favor a large number of spindly stalks as there seems to be a correlation between seed spacing and circumference of stalks, and the spindly nature of the stalks may be due to excellent stooling qualities.

J. S. B. Pratt, Jr.: Naturally, a large type cane is to be desired, but the final answer is tons of sugar in the bag per acre. A large cane is very often a poorer ratooner than the small stick cane.

A. T. Spalding: I prefer a seedling with a medium number of large sticks. Easier and cheaper handling.

H. E. Starratt: Supposing their content to be the same (and also the tonnage) the variety producing the larger sticks is preferable, because of lessened harvesting expense, and because larger sticks strip themselves better.

John C. Thompson: A seedling with a small number of large sticks is to be preferred to a seedling with a large number of thin sticks, provided, however, there is no difference in yield per acre and in sugar content. This would make harvesting easier.

J. A. Verret: For general conditions avoid extremes. But it is a safe bet that as the sticks get smaller, the cane gets hardier and ratoons better, so, arguing from this as the conditions get poorer the most desirable type will have

sticks getting gradually smaller. The idea is to get sticks as big as you can without sacrificing quality.

Mr. Austin: I should prefer a seedling with a few large sticks.

Question 10. Would you plant seedlings in the richest, poorest, or average plantation soil?

H. P. Agce: Average conditions should serve very well. If the canes show promise they can be transferred to poor lands for further trial.

W. P. Alexander: This depends upon the conditions under which you intend to finally grow the cane when it becomes established as a standard variety. There is no doubt that having one test, perhaps the third, under adverse environment, will insure that the cane selected is not a weakling. In any case, check plots, of a known variety must be used for purposes of comparison.

Charles F. Poole: I would prefer average soil, although during the period of five field tests it might be possible to try out all three types.

J. S. B. Pratt, Jr.: There is a big difference of opinion on this question, but I am of the opinion that the seedlings should have the best of care and conditions, until enough material is to be had to test them under adverse conditions.

A. T. Spalding: I would try them on every kind of soil. This is another reason why we should not be too hasty in condemning certain canes.

H. E. Starrat: Seedlings should be grown under the conditions approximating those where they will be grown as commercial canes. If a cane is to be developed for Olaa, I would transplant the seedling in an area of uniformly rich soil, for by doing so, the most promising seedlings would rapidly come into prominence, and could be spread to larger areas, because of their rapid growth.

If the seedlings were planted in uniformly poor soil, growth would be stunted and good seed would be slowly formed.

John C. Thompson: Seedlings should be planted in the richest plantation soil only, to get a quicker start and more seed to spread. On a whole it is better to plant seedlings on average plantation soil, since we are looking for seedlings that will satisfy our average conditions and our poorest conditions. What we want now is a seedling which will do better than our standard varieties on our average and poorest soils, for it will no doubt do well on our richest soils.

J. A. Verret: In general I would put the first crop under good conditions. The selected ones should then be tried under all conditions before being finally discarded. On the other hand, if I was attempting to produce a seedling for some specific set of conditions I would start with those conditions at once. In trying for a mauka cane, resistant to root-rot and mosaic, start by getting tassels likely to give crosses of D 1135 and Tip, D 1135 and Uba, Badila and Uba or any other likely canes having some of the characters you desire. Then plant your seedlings mauka and let natural conditions do the selecting for you.

Mr. Austin: I would plant seedlings in the average plantation soils.

Question 11. Do you consider a seedling arrowing at twelve months not worth selecting?

H. P. Agee: If the cane is otherwise good it might have another trial. Since, however, we should work toward eliminating the practice of cut-back, heavy tasselling at an early age is undesirable.

W. P. Alexander: A cane that arrows over 50% at the end of the first season will not serve as a commercial two-year cane. The ability of cane to lala and not die back will be a deciding factor for a cane that tassels less than 50%.

Sugar per acre per month yielded will determine the fitness of a one-year cane, almost regardless of its tasseling character. Under our conditions we would expect .5 ton of sugar per acre per month, in order that a cane be up to standard.

Charles F. Poole: Seed planted in the fall of one year could hardly be prevented from arrowing in the fall of the following year, or 12 months from then, but seedlings arrowing profusely at 7 or 8 months would not make the impression that those requiring longer would make.

J. S. B. Pratt, Jr.: A seedling arrowing at 12 months may be a good cane. H 109 is an example.

A. T. Spalding: Not for our present system of one crop in two years.

John C. Thompson: I do not consider a seedling arrowing at twelve months worth selecting. The new growth of suckers and the going back of an arrowed cane which is very apparent on our unirrigated fields are undesirable qualities. This is clearly demonstrated by Rose Bamboo when planted on our makai lands.

J. A. Verret: Excessive tasseling is not a desirable character, but it may be indicative of an early maturing cane. There is some demand for such a cane.

Mr. Austin: I consider a seedling arrowing at 12 months not suitable for makai lands, but I would give it a chance on mauka lands.

Question 12. Have you any choice in color of cane, with regard to mauka or makai lands?

H. P. Agee: If we begin our work with any preconceived ideas along this line we should be prepared to change them. We should never discard a cane on account of its color, if this is the only fault it has.

W. P. Alexander: No.

Charles F. Poole: No.

J. S. B. Pratt, Jr.: One may have a preference in color, but one cannot correlate color with a good sucrose cane.

A. T. Spalding: No.

H. E. Starratt: D 1135, a red cane, persists at Mountain View, whereas yellow canes have died.

There may be something in the saying that a red cane or dark colored cane is good for upper elevations.

In 1922 I planted all of the red rind seedlings at Mountain View. No results as yet.

John C. Thompson: I believe the dark colored canes are best suited to mauka lands on account of their ability to absorb heat, and the light colored varieties to makai lands.

J. A. Verret: Very dark canes may produce darker sugar and in that way not be so desirable. This is a very minor defect, as rind color is easily removed in refining.

Mr. Austin: No.

Question 13. In judging a seedling, would you favor an erect or recumbent cane?

H. P. Agee: A choice between erect or recumbent canes should not be made in the early work. It is sugar per acre we are after. If the stalks can lie on the ground without too much rotting they should have every consideration. Erect canes are preferred in Java and other warm humid countries because they say that canes cannot lodge without the stalks dying. This is not the case in Hawaii with many varieties.

W. P. Alexander: Recumbent cane for dry lowland, as a cane which lies down gives greater tonnage. An erect cane for wet mauka lands where a recumbent cane will rot or be rat-eaten.

Charles F. Poole: That depends on the age of becoming recumbent; if it remained erect too long that would indicate lack of weight, and falling all over the ground too soon would indicate lack of vigor and might affect the quality of the juice. I should prefer an erect or semi-erect cane till 10 or 12 months.

J. S. B. Pratt, Jr.: The type of cane depends on the locality in which the selection is to be made. A recumbent cane would be more apt to rot in a wet locality.

A. T. Spalding: Erect or semi-erect to my choice. Recumbent, never for our grassy fields.

H. E. Starratt: Given an equal tonnage, I would prefer an upright to a recumbent cane, for the former is easier to hoe and cultivate, and shades the weeds out. Honohono climbs over a recumbent cane, keeping it wet and covered with trash, causing it to rot and root.

John C. Thompson: An erect cane is to be favored in judging a seedling, since cultivation and harvesting are facilitated and there is less chance for deterioration. An erect cane shades in well and suppresses the growth of weeds.

J. A. Verret: Avoid extremes. A wet district requires a more erect cane than do the dry districts.

Mr. Austin: I would prefer the recumbent cane, but not too much that way.

Question 14. In judging a seedling, would you favor wide or narrow leaves?

H. P. Agee: There is a certain relation between the width of leaf and the size of the stalk. When we use the terms "wide" and "narrow" leaves we should think of them in proportion to the size of the stalk. Using the terms in this sense I think we will find most of our commercial canes to have a medium sized leaf. If a leaf is too narrow the plant is apt to be weak. If it is very wide it shades the field too much and holds down the number of stalks per acre.

I find it hard to overcome a prejudice against a seedling with the wide, thick, pulpy leaf. This may be due to the fact that canes of this sort attract

attention on account of their leaf vigor and often fail because there is not an even balance between stalk and leaf.

W. P. Alexander: A large feeding surface of the leaves is essential. A very broad leaf is not necessary, but a very narrow leaf produces a cane of no account. Such canes may be eliminated.

Where weed growth is rapid, as in wet mauka lands, a cane with a broad leaf is desirable. Such a cane quickly closes in and shades out the weeds.

Charles F. Poole: Theoretically, narrow leaves offer less surface for water transpiration, and would seem to favor a mauka location, whereas broad leaves present more surface to the sun, and the greater water transpiration would be overcome on a plantation with high temperature and plenty of water. But the general performance of the seedling at selection, whether mauka or makai, would settle the question.

J. S. B. Pratt: I would prefer a wide leaf in the Hilo district, a larger sugar-making machine. A wide leaf would not be desirable in a windy or dry district.

A. T. Spalding: Medium to wide leaf would be my choice.

H. E. Starratt: I have made no observations that would correlate wide and narrow leaves with the quantity of the cane.

John C. Thompson: Wide leaves are to be preferred to narrow leaves, which do not shade in as well and which cannot perform the work of the larger leaves. Many seedlings are to be found with large sticks and narrow leaves, which I believe is an undesirable quality. Narrow leaves with thin sticks are permissible.

Mr. Austin: I would prefer the wide leaf.

SUMMARY

The following is a summary of the answers to the questionnaire:

Questions 1 and 2: The favorite varieties growing on the different plantations are: For low lands, Yellow Caledonia, Lahaina and H 109; for high lands, D 1135, Yellow Tip and Yellow Bamboo.

Question 3: All agree that each plantation should conduct its own seedling propagation experiments. This is of the greatest importance, for the cane plant not only changes in different countries, but also in different localities.

Question 4: Among the qualities of an ideal cane seedling are: High tonnage, high sucrose content, early maturing (not going back, however, before August and September), resistance to root-rot, eye-spot, and other diseases, good agricultural qualities, good ratooning qualities. That cane which takes the maximum advantage of the production factors of its environments, hardiness, inexpensive cultivation, Yellow Caledonia type, good crop, erect growth, high vitality, good stooling, and shading abilities, ability to stand over, resistance to drought, good milling qualities, and resistance to insect pests.

The climatic conditions on these islands vary so much, that it would be almost impossible to grow a seedling containing all the above qualities.

That cane which takes the maximum advantage of the above qualities would be as ideal a cane as we could wish for.

Question 5: No one has found a correlation between quick germinating seedlings and high tonnage.

All plant breeders in search of a certain quality, the knowledge of which is not known until the plant has reached maturity, also try to find some visible characteristic at an early part of the plant's growth, which definitely correlates with this quality. By this method, a great deal of time and labor is saved, for, those not showing this correlation may be at once destroyed. This factor of correlation is of the most importance, and should be studied by those propagating cane seedlings.

At Hilo Sugar Co., we believe there was some correlation between germination and large tonnage.

From 500 quick growing seedlings of Lahaina parentage, 103 plants were selected for further trial.

Eleven of these were among the best 20 out of 2,000 seedlings. Seven of these 500 were among the best 21 on the second selection. Burbank found correlation to be a great time, space and labor saving method, the burning of the discarded plants being generally known as his \$10,000 bonfires.

Among some 15,000 *Amaryllis* crosses I found that those germinations showing vigor from the beginning, grew to be the largest plants. On the other hand, those which grew slowly, and seemed weak, gave usually a mutant flower, while the vigorous plants gave a flower either like the pollen or ovule parent.

This also applies to the *Petunia*, the slowest and weakest plants producing sometimes double flowers.

Question 6: Some favor three selections at least, others six and more. One says, "If you are restricted for area, leave the seedlings in the original box, until, by the law of the survival of the fittest, the number is reduced to what can be profitably handled."

It would seem that there should be over three selections.

Question 7: All agree that the ratooning qualities of a seedling cane are more important than its plant qualities, in selection. The seedling plot should be ratooned, and not plowed up after the first selection.

Question 8: As to how old a cane seedling should be when selected, those favoring an early maturing cane favor 12 months, while those favoring a late maturing cane favor 24 months.

Another says that a two-year-old cane will show its susceptibility to rotting, whilst selection proper should be done with young seedlings.

In order to save time, it would seem the proper thing to select seedlings about 12 months to 18 months old.

Question 9: Large and medium sticks seem to be more favorable than a large number of thin sticks.

One member thinks that there seems to be too much prejudice against thin sticks, and that these are generally the hardiest.

There seems to be a correlation between thin sticks and the prolific stooling properties of a cane plant. Under adverse conditions, there is a better chance of getting a good tonnage from a quick shooting cane with thin sticks, than with one with large sticks.

There is a better chance of one shoot surviving out of two or three than out of one.

Question 10: All differ on the kind of soil in which seedlings should be grown. One thinks that it depends where you want to plant them finally. Others, either on the best soil, or under adverse conditions, or on all kinds of soil, or on average soils, and on unfavorable soil.

At the Hilo Sugar Co. we propagated some 2,000 seedlings under somewhat less favorable conditions than plantation cane.

Question 11: The majority think that early tasseling is an undesirable characteristic.

Where it is customary to harvest cane at 18 to 24 months old, the tasseling of a 12-month seedling seems to be undesirable.

Question 12: There seems to be no choice as to color, excepting in one case. It used to be the contention that a dark cane attracts the sun's rays, thus increasing the temperature.

Question 13: Recumbent canes are preferred for dry lands, otherwise erect canes are more favored.

Question 14: Nearly all prefer medium and large leaves, and contend that a narrow leaf is conducive to weakness.

A narrow leaf usually indicates a narrow stick, a large leaf, a thick stick.

A narrow leaf would be somewhat able to withstand drought better than large succulent ones.

Report of the Committee on Boiling*

BY NEWTON CRITES

The report of this committee is to deal with the manufacturing of sugar from the syrup stage to the time the sugar is shipped.

Thirty-six letters were sent out to the men in charge of this work, asking for new ideas and methods tried out during the year. No specific questions were asked, but topics were suggested for discussion. From the fifteen replies received few new ideas were found, and in order to make any report at all it was necessary to draw upon the writer's limited experience at Pepeekeo. As a result the following topics, enlarged upon, are submitted:

COMMERCIAL SUGAR

Clarification of Syrup or Remelt: There seems to be no attempt at clarification of syrup or remelt.

Mr. N. King, of Koloa Sugar Co., allows the syrup to settle as long as possible, while Mr. G. F. Murray, of Hamakua Mill Co., screens his syrup.

* Presented at the Second Annual Meeting of the Association of Hawaiian Sugar Technologists, Honolulu, October 22, 1923.

Here, at Pepeekeo, we screen all syrup and remelt. The remelt is pumped to a tall cylindrical tank where it settles for several hours. It is then decanted through pipes set in at regular intervals down this tank. A great deal of sediment is settled, and all tanks are washed out into the mixed juice once a day.

Use of Chemicals Such as Sal Soda: Only two places report the use of soda ash.

Mr. J. H. Pratt, of Pioneer Mill Co., uses a small amount of soda ash in the remelt, while Mr. W. K. Orth and Thomas J. Nolan, of Ewa Plantation Co., use soda ash to correct acidity in the remelt and low grade pan.

At Pepeekeo, the first part of this year, we did not use sodium carbonate but later, upon the addition of it to the remelt and the low grade pan a noticeable reduction in our waste molasses and ease of handling the low grade was observed. We tried adding sodium carbonate solution to our low grade massecuites after four days in the crystallizers, but with no better results.

Methods of Forming Grain: All replies indicated the use of low grade sugar for seed, with two exceptions.

Mr. Raymond Elliott, of Paauhau Sugar Co., and Mr. F. D. Bolte, of Hutchinson Sugar Co., formed the grain in the pan from syrup to avoid dark centered sugar.

Mr. G. F. Murray installed a new seed mingler of which he says, "The advantages derived from this installation are, increased pan capacity, and from this, a larger grained commercial sugar. The disadvantage is the dark seed grain, which has persisted throughout the crop."

System of Boiling to Produce 97 Degree Sugar: What advantage or disadvantage do you find in making an all syrup and remelt strike, returning all molasses until it is the proper purity for low grade, over repeated back boiling of molasses? How do you make a 97 degree sugar and a 50-52 molasses?

The method of frequently making all syrup strikes, seems to be the general operation since the refinery requested 97 degree sugar.

Mr. J. H. Pratt writes:

We make three grades of first sugar. A straight strike or "A"; all the molasses from the "A" strike is taken back in the "B" strike; all the molasses from the "B" strike is taken back in the "C" strike. The "C" molasses is boiled for low grade. This system is very flexible; if the initial purity is high an extra or "D" strike may be boiled; when the juice is low, the "C" strike may be omitted. It has the advantage of clearing the house frequently, there is no closed circuit for the molasses. Remelt is taken into all three classes of strikes.

Mr. V. Marcallino of Waiakea Mill Co. reports:

Since 1921 we have been boiling all syrup strikes and returning all molasses until the proper purity for low grade is reached. The results have been gratifying, in that the sugar has been of satisfactory polarization and grain size. This year, the purity of molasses boiled for our first low grade has averaged between 51 and 52 and the sugar which has reached the refinery averages about 97.25 polarization.

Mr. W. K. Orth and Mr. Thomas J. Nolan:

We prefer the method in which the molasses is returned to obtain a set purity of massecuite, an "A" massecuite of 80 and a "B" massecuite of 76 purity. This latter

furnishes molasses for the low grade strikes. This molasses we aim to keep at 56-55 purity. With the initial purities of our juices, this is often accomplished with one boiling. But even recognizing the dangers of reboiling, we prefer this system on account of the resulting, even quality of sugar. Twice a week we boil off all the molasses, thus avoiding excessive reboiling. The purity of molasses allows of direct graining without the aid of higher purity material for a footing and gives, under our condition, a good working low grade and final molasses of satisfactory purity.

Mr. F. D. Bolte boils off all molasses once a week, while Mr. G. F. Murray makes a new strike to six mixed strikes.

The first part of the season, at Pepeekeo, we boiled off all molasses once a week and then changed to making one new strike to three mixed strikes, which resulted in our low grade drying much better. This may have been due to the change or it may have been due to the character of the incoming juices. The first part of the year our mixed strikes produced a 97.2 sugar and a 50 purity molasses, but as the season advanced the polarization of the sugar dropped and the purity of the molasses increased. This necessitated a change in boiling, to keep the sugar at the proper polarization with a corresponding low first molasses.

Introduction of Remelt; Where and Why? With one exception, all replies indicated the introduction of the remelt into the pans.

Mr. William Ebeling, of the Hawaiian Sugar Co., does not have any remelt as he uses all low grade for seed.

Mr. Raymond Elliott reports:

The remelt, i. e. our No. 2 and 3 sugars dissolved in clarified juice to about 70 Brix, is then pumped to a receiving tank where it runs into the mixed juice. In this way the remelt is limed, heated and clarified again. The reason why we add the remelt to the mixed juice instead of sending it to the pans is: All of our cars and tanks are of the open type. The No. 2 and 3 sugars from open cars and tanks are far from being clean, and by returning them to the mixed juice most of the impurities are eliminated. Then the question of acidity and alkalinity arises. The house is run alkaline so as to give an alkaline first sugar. The resulting molasses from that is always acid when boiled to blank. Naturally the No. 2 and 3 sugars are acid and that again, is corrected when the remelt is returned to the mixed juice. If we were to take the remelt into the pans, NaOH, or some such chemical that is highly basic, would have to be used in order to bring the No. 1 sugar to an alkaline point.

Mr. W. K. Orth and Mr. T. J. Nolan:

We treat remelt as syrup and work it as such. No benefit is derived from reprocessing remelt by sending it again through the ordinary clarification process. There are no advantages to offset the disadvantages, such as higher sugar in mud, the usual deleterious effect on the clarification of the juice, and the dangers incident to unnecessary heating of sugar solutions. Only special processes, as perhaps double purging of low grades, might improve remelt without prohibitive cost.

At Pepeekeo, we tried introducing the remelt to the mixed juice for two weeks but it upset the chemical control of our continuous clarification system, so that it had to be discontinued. The aim was to aid in the purging of the low grade by eliminating the impurities, but the expected results were offset by the poorer quality of juice produced.

Cause and Prevention of Conglomerates: There were but a few replies to this topic, but the general belief is that conglomerates are caused by poor circulation in the pans, and sticky condition of syrup or molasses.

Mr. W. K. Orth and Mr. T. J. Nolan:

Conglomerates are, in our opinion, mainly due to poor clarification; poor circulation in the pan; lack of skill in boiling; poor quality of seed (uneven); quality of the juice (gums).

Mr. G. F. Murray:

Conglomerates show up in my straight strikes the same as the mixed strikes, though not to the same extent. My experience in the beet sugar business leads me to the conclusion that they are due to the gummy, viscous material in solution in our syrup and molasses, and we can look for no improvement until we improve the clarification of these products.

At the Western Sugar refinery, there was a one hundred-ton pan that always caused the grain to roll up. Shortly after the pan was grained the crystals began to stick together and no matter what the operator tried the results were always the same. The writer saw only one pan of lower purity sugar that did not form conglomerates. The reason given there, was poor circulation in the pan, which the engineers could not remedy.

Washing of Sugar: No new methods or liquids were used in the washing of sugar this year. The amount of water used varies from one pint to four quarts to a forty-inch machine, the quantity depending on the polarization of the sugar needed. Mr. N. King found that adding the water one minute after the machine was started gave the best results.

The use, in Hawaii, of unsanitary tins and buckets in place of a sanitary hose or automatic machine in the washing of sugar is common practice. It seems that when precautions are taken to provide pure water in washing that the benefits derived are offset by the methods of application.

LOW GRADE

Preparation of the Molasses Used in the Strike Such as Heating, Skimming, and Addition of Water: In nearly all mills the molasses is heated to about 160 degrees F. by steam, and diluted to about 80 degrees Brix.

Mr. W. K. Orth and Mr. T. J. Nolan reply:

We heat molasses to about 170 degrees F. by blowing steam into it, we further dilute to 75-80 Brix and agitate during this time by means of a propeller.

At Pepeekeo, all molasses is heated to 160 degrees F. and skimmed to remove impurities that rise with the froth. Molasses, used for low grade work, is diluted to 50 degrees Brix and taken into the pan that way, no extra water being used. In this way the quantity of water can be regulated more closely than by merely opening the water valve at the same time molasses is added to the pan.

Methods of Forming Grain: The general method seems to be to either shock seed or concentrate in the pan until enough grain appears.

Mr. W. K. Orth uses a molasses of 58 purity while Mr. A. L. Grandhomme of Lihue Plantation Co. uses one of 52 purity in graining.

Mr. J. H. Pratt reports:

About 8 or 10 tons of molasses from the "B" strikes is blown up as little as possible, so as not to dissolve the small grain formed when the molasses strikes the centrifugal casing. This is pumped to a separate tank and is used for seed. It has the advantage of saving time, and the evaporation of a small amount of water, and of not having a "dark seed" for the nucleus.

At Pepeekeo, the method used has been to boil about 300 cu. ft. of 52 purity molasses to about 94.5 Brix and drop it blank to a graining tank below where grain gradually forms. There are two tanks, one tank is graining while the contents of the other is taken up and the grain built up with molasses. The main objection was that even though the purity and Brix of the molasses were correct, the grain might or might not be the proper size. Often, under the same conditions, false grain as well as uneven grain appeared. The grain usually had a dark center due to insoluble impurities in the molasses. During the middle of the crop we started to add about one pound of white "Dessert Sugar" five minutes before dropping the blank and boiling to only 92.5 Brix. We got an absolutely uniform clear grain, the size depending on the Brix of the blank. The purity of the waste molasses immediately dropped over one point and the low grade dried much better, giving a uniform seed for our No. 1 sugar.

The use of powdered sugar in boiling blank low grade should certainly improve the formation of the grain, and all operations effected by the condition of the low grade sugar.

Cause of False Grain: False grain in low grade seems the most important factor that prevents the molasses from being properly exhausted.

Mr. W. K. Orth's reply sums up the main reasons for false grain. He says:

Some reasons for false grain are, having the molasses entering the massecuite in the pan at too low a temperature or too heavy; too fast boiling; keeping the massecuite too thin, especially after the pan is half full; foreign grain entering with the molasses charges; too small a quantity of grain to start with; poor circulation in the pan; irregular feeding; great variation in the purity of the molasses for the same strike, if unknown to the pan man.

Mr. G. Giacometti has had trouble with false grain forming in the crystallizers. He says:

However, the problem that has interested us most was, and is, how to lower the purity of our final molasses. With the help of a microscope we can follow and control the formation and size of the grain. We are perfectly satisfied that the massecuites are free of false grain when dropped into crystallizers, but after a day or two false grain does appear. We have tried every combination as to purities, densities, and size of grain, but without permanent results. It is evident under these conditions that we can not hope to exhaust our molasses by extra high density, since this will promote an extra large formation of false grain later on. We are still undecided whether the primary cause is in our mechanical arrangement or in our boiling method. We tried to grain our low massecuites directly from molasses, and from molasses and syrup but with no apparent different results.

At Pepeekeo, I have never seen false grain form in the crystallizers, but when present, it is always found just before the pan is dropped. The reason it does not form in the crystallizers is because the mother liquor surrounding the crystals has been exhausted to a purity of at least 36. The cause of false grain in the pan is that the mother liquor is not sufficiently exhausted before another charge of molasses is taken in, or, in other words, that the massecuite is kept too thin near the finish of the strike. When thick molasses and water are taken in the pan at the same time, the water has a tendency to rise to the top, leaving the molasses below, and as this is concentrated, false grain will appear. This trouble can be avoided by diluting the molasses before taking it in the pan.

Brix and Purity of Massecuite and Purity of Hot Molasses. Can You Make as Low a Waste Molasses from a 55-60 Massecuite as from a 50-52 Massecuite? This topic was not discussed at any length in any of the replies. Merely the Brix and purity of the low grade was given. The question as to the proper purity of low grade for the best exhaustion of the molasses has been brought to my attention several times. From the reports sent in it seems that those mills with the lowest purity massecuite exhaust their molasses more thoroughly. The equipment of the mill has much to do with it, as a lack of machines will necessitate a higher purity and a quicker drying massecuite.

Our average at Pepeekeo this year was, massecuite Brix 98.1, purity 50.5, hot molasses purity 33.3 and gravity purity of final molasses 34.8, while at Lihue Mr. A. L. Grandhomme reports a massecuite of 97.5 Brix, purity 51.4 and a final molasses gravity purity of 34.9. Mr. W. K. Orth had a higher purity massecuite and a higher purity final molasses. He reports a Brix of 100, purity 57-59, hot molasses purity 40.5, and a gravity purity of final molasses of 35.5.

Advantage or Disadvantage of a Large Grain: Mr. W. K. Orth and T. J. Nolan report:

A reasonably large grain, if it can be produced without false grain, gives the distinct advantage of more rapid and better drying sugar than small grain (of otherwise equal strikes), and consequently brings less low molasses back into process. At first sight it appears more difficult to bring the molasses down to low purity with large grain, but in the long run that may not be so when one considers the detrimental effect of the often very low purities of seed and remelt, due to poorly drying grain. A smaller grain permits of faster boiling, and leaves much less danger for false grain forming. A medium grain of about .3-.4 mm. seems, to our experience, to be the most advantageous.

Mr. Chas. P. Bento, of Wailuku Sugar Co., tries to get a grain .5 mm. in size.

The results at Pepeekeo show that the size of grain has little to do with the exhaustion, but the inability of the pan men to keep false grain out necessitates a fairly small grain.

Effect of Acidity of Clarified Juice on Drying of Low Grade: There was but one reply to this topic.

Mr. J. H. Pratt writes:

During the crop we ran for one week with neutral juice, during the remainder of the crop our juice was alkaline to phenolphthalein. No difference could be noted in the drying of the low grade boiled during this week and the molasses was the same purity.

A few years ago most mills carried their juice neutral, or slightly acid to litmus, because the low grade would dry better. There has been a gradual change towards alkaline juice even going as far as alkaline to phenolphthalein, yet there seems to be no difficulty in the drying of the low grade. Was it a superstition, or does the increase in lime remove more impurities to offset the more alkaline juice?

At Pepeekeo, we ran the house .6 acid to phenolphthalein for two weeks, and found the low grade did not dry as well as at .2 acidity since our juice was not as clear.

CRYSTALLIZER WORK

Method Used to Get Maximum Drop. Use of Dilutant, Such as Water or Molasses, and When Applied: Mr. W. K. Orth and Mr. T. J. Nolan replied:

We advocate boiling to 100 Brix, dropping at low temperature, adding slowly 17 gallons of water to 7,500 gallons of massecuite, and keeping in motion about eight days in crystallizers. We found by tests that in eight days we can expect most molasses to be practically exhausted, although eleven days or more would be required in some cases.

Mr. Wm. Lougher, of Hawaiian Commercial & Sugar Co., writes:

We have noticed a very decided improvement in the working of all boiling house products since the installation of the Petree process. Low grade massecuite was especially improved, so that we only were using one-half of our low grade centrifugal capacity, in spite of the fact that we were drying without adding water to the crystallizers.

Mr. Wm. Ebeling dilutes massecuite in the crystallizer to about 93 Brix before drying.

Mr. A. L. Grandhomme adds water to the massecuite, it being in a screw conveyor on its way to the mixer.

Mr. N. King does not add water until after the fourth day when it is added in ten-gallon portions to the crystallizers.

A disputed question at Pepeekeo has been the Brix at which the massecuite should be dropped. Will there be a greater drop by boiling to 99 Brix and diluting to 95, or by dropping at 95 with very little dilution? Several factors enter into the solution, but we have found that a 98 Brix is the most convenient one. In finishing a pan it is boiled about three hours with only water added. After each addition of water the contents of the pan is boiled a little thicker so as to thoroughly exhaust the molasses. With such a high Brix in the pan, too much time is required to thin it down to 95 Brix, as the circulation is so poor that the water evaporates before it has mixed with the massecuite. Our crystallizer capacity is such that we can dilute before pumping to the necessary Brix for drying.

The effect of water added to a massecuite after 96 hours in the crystallizer, and the drop in purity of the molasses with the corresponding drop in temperature, is illustrated in six crystallizers examined during the crop:

Brix of strike when dropped.....	97.6	97.6	98.4	98.7	99.1	99.2
Purity of strike when dropped.....	50.3	51.3	49.4	48.0	51.8	49.2
Purity of hot molasses from strike.....	30.8	32.8	28.9	29.9	32.4	29.6
Purity of molasses in 12 hours.....	29.7	29.9	26.0	28.0	29.7	27.9
Purity of molasses in 36 hours.....	28.3	27.8	26.2	25.7	28.8	26.4

Purity of molasses in 84 hours.....	25.7	26.1	22.8	24.1	25.9	25.1
Temperature when dropped.....	53	56	54	54	54	53
Temperature in 12 hours.....	52	51	51	53	52	52
Temperature in 36 hours.....	47	46	50	45	47	47
Temperature in 84 hours.....	40	35	38	37	37	38
Brix Mass. before drying.....	97.0	95.7	96.9	95.0	96.2	95.5
Purity molasses before drying.....	25.8	25.8	23.3	25.1	27.9	25.5
Hours in crystallizer.....	144	144	144	192	168	192

The results are not very consistent, but show in a general way the effect of dilution of massecuite with water, and the fall in purity of molasses corresponding to the drop in temperature.

Use of Steam or Water in Drying: From the replies received it seems that no water is used in the machines.

Mr. Chas. P. Bento uses steam around the baskets, as does Mr. W. K. Orth, who considers its effect on purity insignificant.

At Pepeekeo, we use from one to two pints of water in the machines and get an increase in purity at machines of 2.3. This is due to the use of water and the fact that sugar sifts through the screens. The latter raises the purity about one point.

HANDLING OF COMMERCIAL SUGAR

Conveyors. Cause of Breaking of Sugar Crystals: Most of the replies seem to indicate that part of the total small grain is due to conveyors.

Mr. G. F. Murray writes:

Any type of conveyor that drags the sugar along in a trough or flume is bound to break up a considerable amount of grain. Conveyors of the grass-hopper or belt type will obviate this trouble.

Mr. W. K. Orth:

We changed the conveyor from screw to grass-hopper, on account of breaking crystals.

Mr. Wm. Ebeling:

Here, we have iron scraper conveyors and I find them breaking and grinding the crystals.

Mr. N. King:

Our scroll sugar conveyor is perhaps not the best, as far as the prevention of crystal breakage is concerned, but we have no trouble to speak of with it.

Mr. J. H. Pratt:

We use both scroll and bucket conveyors and they are both very long. As our average "total small" was less than 19 for the crop, any breaking up of the sugar can not be very serious.

The writer is inclined to agree with Mr. Pratt as the percentage of crystals that come in close contact with the conveyor is small compared with the total number of grains conveyed.

Cooling of Sugar: Mr. J. H. Pratt writes:

Our sugar is cooled by dropping on a revolving disc. We also blow a small current of air through it as it drops into the bagging bin.

Mr. W. K. Orth and Mr. T. J. Nolan:

We use Hersey driers to cool the sugar and believe them of great advantage. The massecuite may be dried very hot, and still the sugar be cool enough when bagged to allow 130 pounds in the ordinary 125-pound bags.

Mr. Chas. P. Bento:

A large sugar bin with a revolving disc, and a twenty-inch vent pipe to the atmosphere is recommended.

There is a general tendency towards cooling the sugar before bagging, the main reasons being to prevent caking and deterioration.

Cause and Prevention of Caking of Sugar in Bags: During the time the refinery sent in reports this year very little caked sugar was reported.

Several reasons for caking and its prevention were reported.

Mr. Chas. P. Bento:

Caking is prevented by cooling sugar before bagging and applying water at machines.

Mr. A. L. Grandhomme:

Caking results when the sugar is not dried well enough, or taken out too soon from the baskets, and when the molasses is too sticky.

Mr. F. D. Bolte:

Moisture and false grain cause caking.

Mr. G. F. Murray:

My sugar is bagged hot and loaded direct into the cars, or, on occasion, piled on the floor. I have had sugar stored in the sugar room for months at a time, but have never experienced any caking in the bags, so I am unable to venture any means of prevention.

J. P. Frank, of Onomea Sugar Co.:

During the past grinding season, some trouble had been experienced due to a defective seal of the water leg on an individual condenser. The vacuum dropped below normal level, subsequently necessitating boiling under a higher temperature; during which time caked sugar was reported. Since the defect was remedied, and simultaneously with the return of normal boiling conditions, the sugar has not caked.

Mr. H. F. Hadfield, of Hilo Sugar Co.:

A film of hot, highly concentrated sugar solution between two crystals of sugar, upon cooling, will harden and the crystals will stick together. I believe this is the recognized theory of caking of sugar.

A big percentage of caked sugar has come from those mills situated along the wet part of the Hamakua Coast. It seems to the writer that weather conditions have a lot to do with the sugar caking, as mills situated in different parts of the Islands handle the sugar in a similar way and yet are not troubled with

caking. Olaa, where the sugar is passed through a Hersey drier, has less trouble with caked sugar than mills in the vicinity of Pepekeo, so that its use improves conditions considerably.

An interesting contribution from Mr. Dean G. Conklin, of Kahuku Plantation Co., is here given:

As a contribution to your report on Boiling House Methods, I beg to submit a description of certain operations at the Kahuku factory which may be of interest:

Straining Raw Juice: During this year, a part of the raw juice has been sent through a 100-mesh Peck screen before going to the heaters. It was hoped to be able to send all the juice in this way, but trouble at the filter-press station made it desirable to leave some bagacillo in the juice in order to form a cake. As will be described later, it was found possible to strain all the juice and still get a good cake. The fine bagacillo removed by the strainer was put back on the mill along with the returned third mill juice. For the greater part of the season we have had excellent clarification and a low molasses. How much of this can be ascribed to the screening is uncertain, as the operation of the screen was interrupted several times during the season for alterations. Nevertheless, the results for the year show such a decided improvement over previous years, that at least part of this must be due to the fine screening.

At the first part of the season, we followed the usual practice of clarifying the first and second mill juices separately. The first mill juice was screened. On the second week in July we changed the system, mixing the juices as in usual practice, straining it all, liming after straining, and thence to scales and heaters. In spite of a very poor quality of juices, there was no difficulty in sedimentation. The settlings were heavily limed, brought almost to the boiling point in blow-ups, and sent to the presses under 25 lbs. pressure. Here again there was not trouble, a perfect cake was formed, filling the frames completely, and washing fairly readily. Our washing arrangement is imperfect, otherwise we would have shown a smaller loss in this operation. A cake $1\frac{1}{4}$ inch thick was obtained, and of remarkably low moisture content, down to 60%. The polarization varied, according to the time of washing, from 1.0 to 5.0%. The runnings from the presses were highly alkaline, and were returned to the raw juice, the lime addition to the juice being reduced proportionately. This made our settling tank station a little crowded, so we resorted to emptying the tanks of the settlings every other fill. We operated under these conditions throughout the balance of the crop, about six weeks in all, with better results, as regards quality and ease of work, than for the rest of the year. It is of interest to note that after the juice was strained, there was no collection of matter on the 100-mesh screen through which the clarified juice ran, showing that the first screening was thoroughly effective. For next season, we are putting in a new battery of cylindrical settling tanks and will have six modern filter-presses at work, therefore we confidently expect still better results at these stations.

Cleaning Evaporators: We have used the method of boiling out the evaporators with strong soda-ash solution followed by weak acid all season, with very good results. Our evaporators have been clean, as shown by the syrup densities for 1922 and 1923 of 56.00 and 64.17 respectively. The work is easy, the men being out of the factory Sunday mornings by 10 o'clock. Our method is as follows: After emptying the evaporators, they are filled to the tube sheet with a 14% solution of soda ash, the manholes of the evaporator are closed, and a manhole on the vapor line is opened. The evaporators are boiled at atmospheric pressure for 12 hours, replacing from time to time the water lost by evaporation. We allow the solution to concentrate the final hour so that when finished it is about one foot below the top of the calandria. The solution is run into a storage tank, and the cell washed, the washings also going to the storage tank until the volume of solution is the same as at starting. Any additional wash water goes to the sewer. The cell is then boiled with a .25% solution of muriatic acid, replacing the acid lost by reaction with the scale, and finally completing by emptying and washing with water. We have found that it is necessary to supplement the soda ash solution with two bags of

soda ash (600 lbs.) each week. There is a saving in both labor and supplies. In 1922 we used soda ash for cleaning, in the usual manner. Possibly, if we were provided with a container, we could have saved considerable expense. As a matter of interest, I give some cost figures:

	1922	1923
Tons Sugar per Day's Labor Cleaning Evaporators.....	13.04	26.14
Cost per Ton Cane, Labor.....	.0086	.0052
Cost per Ton Cane, Soda (Caustic and Soda Ash).....	.0271	.0181
Total Cost per Ton Cane.....	.0357	.0233

I have not included the acid expense, as the records are incorrect. To this financial advantage must be added that coming from the possibility of higher concentration in the evaporators and heat conservation.

Low Grade Boiling; Grain is caught in a 285 cu. ft. coil pan on a 70 purity footing, by shock seeding. We use only about 20 grams of powdered sugar for this purpose. The pan is filled with first molasses, taking about 10 hours, and then cut over to a 600 cu. ft. calandria pan, there being just enough to cover the top of the calandria, and the boiling continued with the first molasses. We generally boil at this pan about 20 hours. Only exhaust steam is used, at 2 lbs. pressure at the calandria, the temperature of the pan being 150 degrees during boiling and 130 degrees when dropped. The average brix is 98.7. The second massecuite is held 11 days in crystallizers, and then dried in a battery of twenty 30-inch machines. Usually, before drying, we add 2 to 4 buckets of a 10% soda ash solution. The machines dry in from 30 to 45 minutes, giving a melt of about 80 purity and a molasses of 96 brix, and 30 to 34 gravity purity. Probably, our good molasses results follow from the fact that we have removed so much fine matter from the juices before liming and heating, but we are more inclined to give credit to our ample pan capacity and slow boiling, and skill at the pans. Since starting this system of boiling, the second pans have always had a grain of uniform size, and there is no difficulty in drying when we mix successive crystallizers in the mixers. It has been suggested, also, that our low molasses is because of the high glucose content, which sometimes reaches 25%, and this may be also a contributing cause. We are satisfied that this high content in glucose is not attributable to inversion. During a short period we carried a glucose-ash balance on juices and molasses, and there was no measurable increase in ratio, rather a decided decrease. That there was no inversion is further shown by our balance statement which records an undetermined loss of only .27% of polarization cane, a boiling house recovery .64% over theoretical; and for the first time in this house a figure for tons cane per ton sugar practically the same as the quality ratio, being 9.57 and 9.52 respectively, with an extraction of 96.0. In former years there has been a difference of 0.5 to 1.0, between tons cane per ton of sugar, and the quality ratio.

Boiler Room Equipment*

By ALVAH A. SCOTT

The subject of Boiler Room Equipment and Boiler Operation has been so thoroughly and ably discussed in previous papers presented at previous meetings, that at first thought it would seem almost impossible to find material for a paper which would form the basis of a real live discussion at the coming meeting. It

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is often the case, however, that in discussing the things that are self-evident and appear big, because they are new, we overlook the smaller, everyday problems which are troublesome and should be discussed.

In the hopes of unearthing some of these problems the writer wrote to all mill engineers in the Territory, as far as he could determine. Sixteen replies were received and in these are points which are well worth mentioning and discussing. Some of these may appear of minor importance, but the writer has found that if the minor things are given proper attention the bigger things take care of themselves.

To give all the replies in full would make too lengthy a report so the various points brought up by each are briefly given.

Mr. Johnson, of Wailuku, writes that a separate Venturi Hot Water Meter installed on the boiling house boilers "has furnished indisputable evidence of the rate and regularity of steam being drawn from these boilers during every hour of the day and night shift, and furnishes the engineer a check on the operating efficiency of the plant." The separate determination of the steam consumed by the boiling house may be a more or less common practice but, if not, it would probably aid in economizing on steam, when this is an important factor, by localizing the points of maximum steam consumption and thus indicate where a change in method of operation might result in a saving of steam. There is no doubt, also, that definite information as to the steam consumed by the crushing plant and the boiling house separately removes a possible cause of friction, between the engineer and boiling house staff, which is liable to occur when fuel economy is the watchword. It is human nature to blame the other fellow unless we have definite information to the contrary.

Mr. Akana, Acting Engineer at Kilauea, writes as follows:

One very minor point that is new to us, but which is undoubtedly used elsewhere, consisted in putting a sliding gate in the bottom of our smokestack flue outside the boiler. At night when the mill is shut down this gate is opened so that the smokestack draws the air through here during the night instead of through the boilers. We find by utilizing this gate that our boiler temperature in the morning is 40 degrees higher than is the case when this gate is not used.

To factories operating on single shift and who do not already have an arrangement as above this may offer a worthwhile suggestion.

Mr. Chalmers, of Waiakea Mill Company, points out in his letter that they intend to overcome, if possible, a shortage of fuel by increasing the heating surface of two of their 7x20 return tubular boilers without any change in boiler size. This will be done by using 3" tubes in place of 4" which will increase the number of tubes from 118 to 186 and the heating surface by 900 square feet or 450 square feet per boiler.

Mr. Chalmers feels confident that the change will work out, as he states it has done so on plantations where it has been tried.

Mr. Purcell, of Ewa, reports a marked improvement in conditions in the power house, where the steam is mostly used from two Stirling boilers equipped in 1921 with superheaters. No definite data is available, however, as performance records were not kept. Superheating of steam is practiced very little in the

island factories, and it is doubtful in most cases whether there would be any economic benefit. But, it is possible that under certain conditions and steam requirements they would effect a saving. It would seem to the writer that definite data would be well worth obtaining.

Mr. Purcell also reports that a compound, duplex pump of the outside packed plunger type, installed to replace two worn out feed pumps, has given splendid service. It is equipped with automatic regulator, is fitted with metallic packing and, with the exception of a turn of packing added all around a few weeks after it had been put in use, has required no adjustments or repairs. He further adds that home-made tube blowers installed on their four tandem boilers have proven very satisfactory.

The old small boiler feed pumps with hand regulation are rapidly giving way to automatically regulated pumps of the general type mentioned by Mr. Purcell, and are of ample capacity to handle, in most cases, all of the work. These new installations have always given satisfaction in every respect.

Mr. Craik, of Hamakua Mill, brings up the point of electric arc welding of boiler seams and flues: "Would the annoyance caused by leaky seams and flues be greatly reduced if seams were electric welded after riveting and all flues electric bead welded after being expanded?"

Mr. Craik's question is prompted by his own experience in repairing some boilers by this method and I quote from his letter in regard to same:

We had considerable trouble with two of our 7x20 boilers, which leaked badly at the first and second course circumferential seams and flues. It is history that these boilers always did leak at the seams and flues since they were installed new, during the close season of 1923.

Every "move on the board" was tried by skilled boilermakers to repair the leaky seams and flues. The loose rivets were cut out, riveted, the seams carefully caulked, and the boilers retubed. Each boiler successfully stood a water test of 150 pounds, but when steaming they again developed leaks, more serious than ever, at the same seams and also at the flues.

Enough tubes were removed to allow a skilled welder to work inside and the faulty seams were electric welded inside and outside to almost the waterline. The flues were bead welded after being expanded and beaded in the usual manner.

Since this electric welding work was done two years ago we have had no trouble whatever with these boilers.

Mr. Daniels, of Pioneer Mill, brings to our attention a method of handling excess bagasse when the fireroom gets filled. He states that they installed an 8-inch blower driven by a 5 h. p. motor at 3065 r. p. m. to blow their surplus trash over into a vacant lot 200 feet away. The blower was fed automatically by a chute connected to the main carrier. At the end of the grinding season all the low grades were boiled off, using this trash as fuel by blowing this pile of approximately 200,000 cu. ft. back to the fire room, through a 16-inch pipe with an 18-inch blower driven by a 50 h. p. motor at 2,100 r. p. m.

Not many plantations are blessed with this extra amount of fuel but the above suggests a method of solving the problem if one is not prepared to bale the trash. Pioneer Mill intends installing a press in the future.

The above suggests the fact that Wailuku Sugar Company have a blower installed in their carpenter shop for handling their sawdust and it is their intention to blow same over to their fire room to help out the fuel problem.

Mr. Duncan, of Olaa, in his letter gives his experience in securing a heavier blanket over the grate bars by a change in the angle of same. As he also brings up points for discussion, in connection with the burning of molasses, we quote here as follows:

The only change we have made this year has been to lower the angle of the furnace grate bars from 50 degrees to 40 degrees from the horizontal. Owing to this steep angle the bagasse would slide to the bottom of the furnace, forming a heavy blanket there and gradually thin out at the top. It was impossible to keep the excess air to a minimum, on account of this light blanket being sucked off the grate and up the smokestack before combustion had taken place. Since changing the angle there is now quite a heavy blanket at the top before it starts to slide to the bottom. In this way the boilers can be forced when the necessity arises without losing everything lying on the grates, combustion taking place when it should.

One considerable source of trouble we are experiencing is the excessive amount of clinker forming on the furnace walls and on the top of the bridge wall, for about three feet into the so-called combustion chamber.

All of our molasses is burned by spraying it on the bagasse as it leaves the last mill, and, as we all know, it is the molasses which is the cause of the clinker. We have also tried burning it with the use of a burner, similar to an oil burner, but with no better results. I think a little discussion on the subject of the proper method of burning molasses would be beneficial. I am aware that several mills are burning their molasses in a separate furnace, using no bagasse, but a few interesting points for discussion would be:

What is the advantage of this method over that of burning molasses and bagasse together?

Is the total heat recovery greater or less by this method than the combined method?

What percentage of the total steam is generated by the molasses alone?

Mr. Johnson, of Wailuku, states, in connection with burning molasses, that they "have been experimenting to some extent on burning waste molasses in conjunction with bagasse." They have found "that by applying the molasses, heated to about 140 degrees F., in a fine spray over the bagasse as it leaves the last mill" they "experience very little difficulty in the furnaces with clinkers or burnt grate bars." The writer is also aware that in other factories where molasses is mixed with the bagasse before burning, there is less trouble with clinker if there is an opportunity for the molasses to become well mixed with the trash before reaching the furnace.

Mr. Anderson, of Papaikou, states that they have had an ample supply of trash during the past season and attributes this, in a certain measure, to the cleaning of the boilers. The following is from his letter which also gives the method of cleaning the outside of the tubes in the off season:

The thorough removal of ashes at the end of the week has a lot to do with the conditions of the following week. We steam down our boilers on Saturday and the removal of the ashes and clinker we have let to a contractor who supplies the men and sees that the work is done as required. I would say that the contract is the most satisfactory method of cleaning boilers.

The cleaning of the boilers (externally) in the off-season is a job that usually takes up a lot time, and a job that the men do not like. Last off-season I fitted up a sandblast and applied it to do the cleaning, and I got very good results.

The tubes were cleaned much better than when done by hand, and with a few bent pieces of pipe it was possible to reach in places where the hand could not. I consider that this saved a lot of time, several men, and we had a better job when finished.

Another thing which helps the fuel situation is an even running of the mill. A mill that is running on a high tonnage of cane per hour and then shut down for lack of cane, is harder on the trash pile than when it is running a little slower and can keep going.

Mr. Dunn, of Honouliuli, writes that the only addition to fire room equipment is the installation of a boiler feed water filter. This filter was designed by Mr. Dunn and consists of two identical units which can be used in series, in parallel or singly. This allows of one unit being cut out and the filtering medium changed without shutting down the whole installation. The filtering medium used is excelsior, which is contained between perforated plates, one top and one bottom forming a cartridge which can be lifted out bodily for changing.

Mr. Dunn also calls attention to a safety device, which he describes, for recording water levels in boilers, and he also suggests a method of placing buckstays in the masonry of a boiler setting. The following referring to the foregoing is taken from his letter:

I do not know whether the following is in line with the subject of your report, as I have not, to date, had the opportunity of demonstrating it, but it was brought to my attention a short time ago, and appealed to me very strongly, as an important factor in boiler room equipment. I have in mind an instrument, which I believe has recently been placed on the market, for recording water levels in boilers. To give you a definite idea of what the inventor claims for his device I will quote from his article:

"The instrument makes a written record of the height of the water in the boiler throughout the 24 hours, and in addition rings a bell whenever the level is either too high or too low. A mechanically operated pen draws a red ink line on a circular, clock-driven chart, and this record indicates graphically all the important facts which need be known regarding the care the boiler is receiving. The red line shows exact time when boiler was 'cut in' and 'cut out', when it was banked for the night, when it was 'blown off', and when in operation. Foam in the boiler actuates the bell signal in the same way as would low water, and the ringing will continue until this undesirable condition is corrected. The water gauge is illuminated sufficiently to make its markings visible 50 ft. away."

If such an instrument will do all the inventor claims, it will minimize dangers in steam boiler operation, and lower insurance rate materially.

Personally, I think such a device is almost a necessity, particularly where unskilled operators are employed.

It has been the writer's experience that, the conventional method of placing buckstays in the masonry of boiler setting is erroneous, due to the fact that many of the stays become burned out and broken, and can not be replaced without tearing down the brickwork surrounding the stays.

To eliminate these conditions the writer suggests that buck stays be placed in conduits. This would prevent, in a measure, the breakage of stays, as it would afford an air circulation around the stays, and offers an easy method to make replacements when necessary, at a minimum cost.

Mr. Hughes, of Hawaiian Commercial and Sugar Company, offers the following interesting contribution, and as it touches on many points which should be of interest to all, his reply is given in full as follows:

During the past season, operations were carried on without the use of oil as extra fuel, this being an improvement here over previous years' work.

This improvement we attribute to the burning of waste molasses; changes in the furnaces, which have allowed a more efficient combustion of the bagasse; converting two oil burning furnaces into bagasse furnaces, thereby adding two 300 H. P. boilers to the high pressure steam line; saving of heat due to the Petree Process eliminating the mud press station, and saving of heat due to the Dorr Clarifiers. A brief description of these different points will be of interest.

When extra fuel was required we used molasses in conjunction with the bagasse. Owing to the limited space available for the storage of surplus bagasse fuel, and there being objections to blowing and storing it outside the mill building, we did not accumulate as much surplus as we might have. This surplus could, in turn, have been used for drying-off purposes at the end of the season, but during this period wood and molasses were used.

This extra fuel was required only when the following conditions prevailed:

When grinding at a very low rate of speed, so that an insufficient supply of bagasse entered the furnaces, stoppages due to no cane, breakdown delays, choking of the mills due to the large quantity of juice and mud returned to the mills from the clarification system, and the polishing of the rollers while Petree Processing.

Six furnaces were arranged with molasses burners, and, when required, any number of these furnaces could be supplied with molasses as extra fuel. These furnaces are of the regular bagasse or Dutch oven type.

A small amount of bagasse is fed into the furnaces, about one-third of the quantity that would be used when firing with bagasse alone, while the molasses was fired through the burner from the front end directly above the fire-box. Live steam is used to atomize the molasses and exhaust for heating it to a temperature of 170° F., a pressure of 75 lbs. being maintained at the burner.

The molasses burner used is a simple combination of pipes, arranged similar to that commonly used for oil burning, provided with a distributor head to which the steam and molasses piping is connected.

The boiler tubes were blown out with a steam hose every eight hours, to remove the deposit of potash which was finally collected at the flue uptake, a door being provided for that purpose.

When all available bagasse storage space was filled with surplus bagasse, an outside electrical load of 300 K. W. to 600 K. W. was taken over by the mill plant in addition to the regular mill load. This extra load was taken care of regardless of the amount of cane on hand, and throughout Sunday shutdowns, the load dropping considerably on Sundays. While carrying this extra load, and the mill grinding at the rate of 110 to 120 tons of cane an hour, it became necessary at times to open up a 12" exhaust valve to the atmosphere in order to use up steam. With the grinding rate in excess of 95 tons an hour molasses would not be required.

A change in all the bagasse burning furnace grates proved to be a beneficial one. Bagasse, when fed into the furnace, takes the shape of a long thin wedge, with the sharp end lying at the top of the step ladder grates. At this point the layer of fuel is very light, and a good draft quickly removed the fuel from the grates, thereby allowing the air to short circuit through this space, while the heavier layers of fuel lower down in the furnace remained a smoldering mass until the upper grates became covered again.

To remedy this condition, the air spaces between the slanting, or step ladder grates, were blanked off at the upper end, to prevent dislodgment of the thin layer of fuel at this point. The floor, or flat grate area, was increased in proportion to the decrease in area of the step ladder grate. The free space, or space between the floor grates, was

considerably increased, as was the space under these grates, this being done to prevent the accumulation of ash under the floor grates from blocking off the air passageway.

We found this to be a great improvement. The bagasse burned freely and evenly, maintaining a higher and more uniform temperature as well as a more uniform record of CO_2 , indicating a more efficient combustion of the fuel.

Two 300 H. P. boilers with a combined heating surface of 6,345 square feet, formerly equipped with oil burning furnaces, and used as boosters whenever the demand for additional steam warranted, were added to the high pressure line as live units, as continuous generators, by changing the furnaces to the bagasse burning type. With this change made, we removed all oil burners, likewise the temptation to open up the oil, which the firemen had become so accustomed to doing that they thought it was impossible to get along without it.

The Dorr Clarifier and Petree Process are responsible for a great saving of fuel, by their eliminating the mud press and filter press stations. We had thirteen 34" frame mud presses in operation, and eight 34" frame clarified juice filter presses, which, with their large radiating surfaces and hundreds of draw-off cocks, liberated a tremendous amount of heat. The clarified juice now enters the first cell of the evaporators at an increase of 18 to 20° F., over the old system. The immense benefit from the wonderfully improved clarification was reflected in the boiling of both commercial and low grade sugars. All sugars dried more rapidly and with less effort, this being especially noticeable in handling the low grades, so it is clearly obvious that a considerable saving of steam was effected here.

The Peck Strainer is without a doubt responsible for a good share of the saving at this station, by the strainer removing practically all the cush-cush from the juice before liming and heating takes place. The strainer removes a large percentage of very fine bagasse that would pass through a 100-mesh screen, indicating that the cake of cush-cush deposited on the periphery of the screen acts as a very fine filtering medium. All this cush-cush removed by the strainer is returned to the mills and adds to the fuel supply.

Here, the Peck Strainer and the Dorr Clarifier were installed in the same season, and it would only be a wide guess to say how much of a saving in fuel either one, or the other, is responsible for.

The Uehling indicating and recording CO_2 instruments have given much more satisfactory service this past season, due to the installation of a small and inexpensive filtering device that screws on the end of the sampling tube. This device consists of two carborundum discs about $\frac{1}{2}$ "x4" in diameter, bolted through the center and held in a suitable frame. All the gas drawn through the sampling tube must filter through these two discs, and the gas lines are kept free of ash.

We have installed in the fireroom this season, our second Alberger centrifugal boiler feed pump. This is a duplicate of the one now in use, which is a four stage turbine-driven pump that has given excellent service at an extremely low cost for upkeep and repair.

Other replies were received but had nothing particular to report. Many others were not heard from. Lack of time may have been the reason in many of these cases, but it is hoped that this paper will have something of interest to all mill engineers, and that they will have had opportunity to read it and be prepared to discuss the various questions brought up.

Miscellaneous Reports of the Chemical Section*

COMPILED BY S. S. PECK †

In the absence of the Chairman of the Chemical Section of the Association of Hawaiian Sugar Technologists, I beg to announce that several very interesting reports were received as contributions to our annual meeting. Unfortunately, owing to unforeseen difficulties and lack of time, these reports could not be published in full, but I am presenting their salient features, calling attention to the valuable points brought out, together with a summary of results.

Raymond Elliott contributed a very interesting report on the cane borer injury, in which he presents the results of a very thorough investigation, conducted by himself at Paauhau. Representative quantities of cane were cut from whole fields, the sticks then divided into groups according to whether they were sound, borer-infected, or with or without rat injury. The writer kept a count of the rat-eaten cane as well, in order to ascertain whether there was any connection between rat-eaten cane and the borer injury.

Mr. Elliott reports an average of 28% infestation by borer on the quantity of cane examined of all varieties, the infestation of the different varieties being as follows: Yellow Caledonia 34%, H 109 29%, D 1135 9%. Two percent overall was found to be both rat-eaten, and borer-injured.

To emphasize the damage wrought by these pests, Mr. Elliott calls attention to the fact that the quality ratio has increased on an average from 7.78 to 12.85 over all experiments conducted on Caledonia and H 109 canes. Computing the loss in dollars and cents, it amounts to 1.9% on sugar per acre, or 17.3% in actual money.

F. D. Bolte reported on the subject of "Influence of Lime on Boilinghouse Purities," which report is all the more valuable because it represents actual working conditions throughout a number of years.

The tabulated results show the following interesting facts: The lime used per ton cane was increased from 1.07 lbs. during 1915-1921 inclusive, to 1.26 lbs. in 1922-23. Correspondingly, the increase in purity rose from .58 to 1.75, but, on the other hand, the drop in purity from No. 2 massecuite to No. 2 molasses, and from No. 3 massecuite to No. 3 molasses decreased from 12.8 to 8.7 and 10.2 to 8.5 respectively, giving a higher gravity purity waste molasses for 1922-23 than previously, i.e. 42.3 against 40.5. The amount of lime used did not seem to affect the drop of purity in the first boilings. In enclosed tables Mr. Bolte shows the relationship between the quantity of lime used and the corresponding change in purity from year to year, also the averages for the periods together with the final molasses figures. The boilinghouse recovery and efficiency

* Presented at the Second Annual Meeting of the Association of Hawaiian Sugar Technologists, Honolulu, October 22, 1923.

† Acting Chairman, Chemical Section.

figures are also given, showing 2.49% increase in recovery for one degree increase in purity, and 3.37% for 2 degrees increase, figuring on the same gravity purity molasses.

In his recapitulation, Mr. Bolte strikes the keynote of his report when he says that while it is better to use too much lime than too little, it is best to use just the right quantity. The correct amount appears to be about 1.20 lbs. per ton cane, varying with the acidity of the juice, and the kind of lime used, giving a slight alkalinity to red litmus paper on hot clarified juice, corresponding to .15% acidity against phenol and N/28 KOH solution, using 1.5 cc. of it to titrate 10 cc. of the juice.

Mr. H. F. Hadfield contributed a report on "Clarification," and it is rather unfortunate that this could not be published in full. After defining the term "clarification," and describing the process with its attendant chemical and physical changes, Mr. Hadfield emphasizes the importance of correct liming, dwelling on the methods in use for determining acidity and alkalinity as a guidance to liming. The great importance of heating the limed juice to the right temperature and for the right length of time is then mentioned, calling attention to the fact, that there is apt to be a variation in the precipitation and the subsequent rate of settling. The character of the impurities, and their relation to the sugar in solution is pointed out, with reference to the viscosity of the massecuites and molasses.

The much discussed topic as to the poor filterability of Hawaiian sugars is next mentioned. It seems to be the general opinion that this is directly due to neglect in clarification, and the presence of suspended solids in the juice. The writer quotes Messrs. Peck, Welle of Crockett, and Prinsen Geerligs on the subject, the essence of which is, that finely divided solid matters held in suspension, when heated with lime, will change into a hydrolized gummy matter, enter the solution, and go through the whole process. In each of the quotations, emphasis is laid on the importance of the removal of these suspended particles from the juice by screening. Kopke's turbidimeter was found to be a useful instrument for the measurement of the brightness of the clarified juice.

Tests on 96° sugars show .06 to .005% suspended matter. It was surprising to find, that practically the same quantity of suspended matter was found in plantation white sugars polarizing 98°-99°. In determining the suspended particles in juices and sugars, the writer found the Vacu-filter very convenient, in fact superior to the Gooch crucible.

Experiments show, that raw sugar contains suspended particles not only in the adhering molasses, but also within the crystal itself. This seems to confirm the theory, that sugar from a supersaturated solution of dirty syrup is apt to crystallize around a minute particle of fiber or suspended matter, and build up the crystal around it.

In screening the clarified juice or syrup, one should not lose sight of the fact that the wear on the screen, due to both mechanical causes and the corrosive action of the juice is great, and on at least one occasion the writer has found, that greater amounts of particles than usual were getting into the sugar, because the perforations of the screen were worn to three times the original size. The usual 100x100 mesh screen apparently will not keep out the very fine particles

of fiber; to partly overcome this difficulty a 200x200 mesh screen will be of great help. This 200x200 screen is apt to get clogged up if it is used alone, but in conjunction with the 100x100 screen, or rather supplementing it, it should keep clear.

Reviewing the process in the refineries, the writer, quoting from Mr. Welle, finds that the experience in the refineries is the same as in our own factories, i.e. the suspended particles still remain in the sugar after purging the sugars with affination syrup. Upon being melted, the crystals liberated the occluded particles, the whole forming a brown, dirty looking liquid. These melts are then mixed with kieselguhr, and filtered through presses under pressure. It is at this point that the trouble is experienced, because with most of our sugars it sometimes takes 3 to 4 times more kieselguhr, to keep the rate of filtration within the allowable time limit, than with foreign sugars. Strange as it may seem, the soluble non-sugars remain practically the same before and after filtration.

We all know that press juice contains no suspended particles. This suggests that filtering the whole clarified juice through filter presses may solve the difficulty. But the question arises here as to whether this is within the scope of our factory policy or not.

The questionnaire sent out to various members of the Association brought out the following points:

1. The strainers used at the mills varied in size from 9 to 100 mesh, or from 64 to 225 holes per square inch; subsequently the mixed juice contained between .12 and .68% of suspended particles.
2. On clarified juice 50 and 100 mesh screens were used, and the percent suspended matter in the commercial sugar was found to be between .07 and .005. Nobody has tried 200x200 screens.
3. Those who screened the cold mixed juice over a 100 mesh screen, find the mud slimy, but this difficulty was largely overcome by overliming the mud.
4. Several of the factories add lime to the mud, the press-juice being returned either to the mixed juice or clarified juice.
5. All agreed that at 190° F. the juices settled poorly, while at 240° F. the juices foamed in the settlers and took longer to settle.
6. All agreed that slow drying of low grades was mostly due to poor clarification.
7. Replies indicate that no relationship between season and quality of low grade sugar was found.
8. Mr. King at Koloa found a consistent relation between the clarity of juice and its phosphoric acid content, but no relation in the rate of settling. Lower fields contained more phosphoric acid than did the upper ones. Phosphoric acid variables in different varieties of cane affected the clarification differently.

In conclusion, Mr. Hadfield wishes to thank all the members who assisted him with contributions to his report.

A most complete report was sent in by V. Marcallino entitled "Blank Boiling," the subject being treated in a very thorough fashion. The contributed data and information will no doubt be very valuable to those practicing blank boiling. The salient results, as indicated by the answers sent in to the questionnaire, are given below in a systematic manner:

1. The only treatment the molasses receives before string-proof boiling is steaming, with the object of dissolving the fine grain which might be present and which otherwise

would cause trouble in the subsequent purging. In connection with this, the writer refers to Prinsen Geerligs' book "*Cane Sugar and Its Manufacture.*"

2. The molasses from which blank boiling is done should be reduced to 51-56 purity; with this initial purity two boilings will be required to obtain a satisfactory final molasses of say 38 gravity purity, the last boiling to start with at least a 40-44 purity. A table of purities submitted by Mr. Bolte, from Hutchinson, shows the best results from 1916, when starting with a syrup purity of 88.6 a final molasses of 39.65 was obtained, the intermediate low-grade purities being as follows: No. 2, 52.03; No. 3, 42.26. A table of Waiakea results for the past three years is also given.

3. The answers sent in seem to indicate that there is no advantage of boiling back molasses under 40 purity; the drying becomes slower, the yield smaller, and besides, it becomes a question of storage tanks and centrifugal capacity.

4. As to the density to which low grades should be boiled, the limits of concentration as indicated by the answers are 90 to 96, depending on local conditions. Here the writer again quotes Prinsen Geerligs.

5. With a decreasing purity of the last massecuite, an increasing density is desirable to obtain a goodly crop of crystals.

6. In regard to the temperature at which the low grade boilings should take place, this ranges between 138 and 155° F., with a corresponding vacuum.

7. In almost every case, the massecuite is discharged at the temperature at which it was boiled.

8. Only a very few members had experience with the brasmoscope as an aid to boiling, though without doubt it is a valuable instrument. Mr. Marcallino calls attention to Bulletin No. 20, of the H. S. P. A. Experiment Station, in which Noel Deerr describes this instrument.

9. None of the factories practicing blank boilings use recording vacuum and temperature gauges, though their value is universally recognized.

10. No one has reported any experience with the refractometer, and Mr. Marcallino again quotes Noel Deerr in his "*Cane Sugar.*"

11. Opinion is divided regarding the rate of cooling. Most seem to agree that speeding up the cooling tends to produce false and small grain.

12. The average temperature at which the massecuite is sent to the mixer is about 86° F., some reporting as low as 77, some as high as 104.

13. How many days after boiling is this temperature reached? In the case of No. 2 this is about 3-10 days, in No. 3 about 6-7 weeks, and in No. 4 about 3 months. (Answers to this question seem to indicate the length of time before drying rather than the number of days required to reach the questioned temperature.)

14. Opinion differs as to whether crystallization is complete at the above-mentioned temperature (86° F.), some stating that the crystals will keep on growing thereafter.

15. Tables and graphs submitted by Messrs. Elliott and Bolte show the drop in temperature day by day for different types and sizes of cooling tanks.

16. Replies indicate that in small or flat iron containers the cooling and crystallization proceeds more rapidly than in big or wooden tanks.

17. All the members who have contributed, recognize the disadvantage of discharging successive strikes into the same tanks; the result is uneven grain, and of course the rate of cooling is slower.

18. All agree that each strike should be dried separately.

19. The practice of partially cooling each strike in separate tanks, say for one week, and then pumping it into larger tanks for further crystallization, is advantageous from the grain standpoint, according to Messrs. Spreckels, Bolte, and Marcallino.

20. Opinion divides as to the harmful effect of slow discharging of the massecuite from the pan. Some believe that no grain forms in a string-proof strike for the first few hours at least, others find that if the massecuite chills, false grain forms.

21. Answers to the question, "What is the result when the massecuite flows slowly through long gutters and pipes?" are the same as in paragraph No. 20.

22. Foaming is caused, in most cases, by boiling at high temperatures, sometimes on account of overliming. The preventative is obvious, and no one suggests a cure.

Mr. Marcallino again quotes Prinsen Geerligs on the subject.

23. In order to prevent foaming, the boiling temperature should not exceed 155° F., though the exact limit is not known.

24. If a massecuite is unavoidably overheated during boiling, cooling it down in the pan before discharging is not always a remedy.

25. Nothing definite can be said regarding the drying qualities of a foamed over massecuite.

26. When boiling string-proof, the size and character of the resulting grain may be controlled to a certain extent by regulating the density; a heavy strike as a rule will yield a thicker crop of crystals, and a correspondingly lower molasses.

27. All members agree that a better exhausted molasses can be gained from fine grained than from coarse grained massecuite.

28. As a general rule, low grade massecuites which dry slower yield a lower purity waste molasses, provided the slow drying was not caused by mixed or false grain. In the latter case, grain escaping through the screen will make for higher molasses. With equal purities, and grains of a similar size and character, that massecuite which is more concentrated will dry slower and will yield the better exhausted molasses.

29. Opinions differ as to the length of time for complete crystallization. It depends largely upon individual equipment. This question was already touched upon in paragraph No. 13.

30. The appearance of grain in the pan before striking, either by accident or by intention, ought to be avoided in low grade strikes to be cooled at rest.

31. Regarding inversion, it is a well known fact that in most factories the molasses products have an acid reaction, for the purpose of obtaining some idea of the degree of acidity, Mr. Marcallino describes a method for determining the acidity.

32. Actual loss due to inversion, during storage of massecuite, is reported by two members, though it is noted that it is extremely difficult to obtain a representative sample from a large tank of massecuite at the time of drying, for the reason, that the sugar tends to settle to the bottom while the top is foamy. Mr. Elliott presents some very interesting tables on No. 2 and No. 3 massecuites held in storage; there appears to be no deterioration in his case.

33. In answer to the question, "What are the causes of slow drying?" the members have the following to offer: High density, high viscosity, excessive small grain, low purity, foamy massecuite, too much lime, too cold massecuite.

34. To aid drying, the following special practices are noted: Reducing the density with water before drying; adding hot molasses before pumping the massecuite to the mixer; steaming it a little, and using a small amount of water in drying.

35. The available sq. ft. of screen surface per ton cane per hour for string-proof massecuites varies from 2.6 as the lowest, to 7.86 as the highest, a wide variation.

36. Opinions differ as to whether there is any advantage of boiling to say 95, and then diluting to 92, as compared with boiling to 92 and not diluting. Of course, it is known that in the case of heavily concentrated massecuites, the water added will first be taken up by the mother-liquor for the reformation of the hydrated combinations of sugars and salts.

37. The following are the chief causes of a high waste molasses purity: High purity mother-liquor, insufficient concentration, much small grain lost in drying, of water for dilution, low glucose ratio, poor screens, too much lime used, high glucose-ash ratio, unripe cane, insufficient centrifugal capacity, and poor arrangement of low grade tanks. The writer quotes Geerligs on the subject of high molasses.

38. When a refractory low grade massecuite is encountered, its drying qualities may be improved somewhat by allowing it further time to age.

The writer concludes his report with an enclosed calculation from Mr. W. v. H. Duker on required pan and cooling capacities for blank boiling.

The above reports contain some rather extensive tabulations which have not been published, but will be circulated during this meeting.

Finally, your sub-chairmen extend heartfelt thanks to all those who have aided them in compiling these reports, and if some advantage will be derived from their efforts, they will be amply rewarded.

Standardization of Sugar Factory Equipment*

By G. H. W. BARNHART

In Noel Deerr's Circular 17, printed in 1913, an attempt was made to arrive at the necessary capacities for a Standard Factory. Since this publication, conditions have changed and with them requirements have necessarily changed.

Following are the requirements as indicated on three different occasions:

	Noel Deerr	Horace Johnson	William Searby
Boiler Heating Surface (sq. ft.).....	500	....	....
Juice Heaters (sq. ft.).....	40	30	35
Settling Tanks (cu. ft.).....	60	72	72
Filter Presses (sq. ft. filtering area).....	100	120	120
Evaporator—Quadruple Effect (sq. ft. H. S.)	225	290	300
Triple Effect	170	215	215
Crystallizers (cu. ft.).....	250	362	362
Coolers (cu. ft.).....	...	1467	1467
Centrifugals (sq. ft. screen area)			
Shipping Sugars .....	...	3.0	2.5
Second Sugars .....	...	4.5	5.0
Total	6.0	7.5	7.5
Vacuum Pans (cu. ft.) (ratio 1:1).....	45.0	55.0	60.0
Vacuum Pump Displacement (cu. ft.)			
Quadruple Effect—Dry	8.6		
Triple Effect—Dry.....	11.5		
Pan (per sq. ft. h. s.).....	0.4		

It will be noted that the requirements for evaporators, pans and centrifugals have consistently increased. In a publication by the writer, which is to be printed and distributed to members of the Association of Hawaiian Sugar Technologists, data and some discussion are given covering some of the apparatus mentioned above. For further discussion the reader is referred to the "Report of Committee on Standardization" by W. v. H. Duker, commencing on page 349 of the *Hawaiian Planters' Record*, Volume XXI.

Boiler Heating Surface: So-called standard practice indicates 450 square feet of boiler heating surface per ton of cane ground per hour. Several items affect this figure. First, we have a variation in cane fiber from 9 to 15 per cent.

* Presented at the Second Annual Meeting of the Association of Hawaiian Sugar Technologists, Honolulu, October 22, 1923.

Other conditions being equal, this indicates a variation of 25 per cent from the average of 12 per cent, and a boiler which operates economically with cane fiber at 12 per cent will be pressed when the fiber approaches 15 per cent. Since the power consumption by the mill varies almost directly as the fiber in cane, it is conceivable that lack of the ideal amount of heating surface may result in insufficient power as the fiber increases. Water-tube boilers are conceded to be more efficient than the fire-tube type, and in calculating boiler horsepower it is allowable to use ten square feet in water-tube and twelve square feet in fire-tube boilers per b. h. p. A third consideration is the economical or practical temperature of the escaping flue gases. A fourth is whether or not there is a surplus of fuel. Finally, the extent to which the "extra use of steam" is practiced in the factory i. e., whether a quadruple effect is used instead of a triple, or a pre-evaporator is used to supply vapors for heating, etc., will determine whether or not the supply of bagasse is ample for all requirements.

Several factories have found it necessary to function with but 70 per cent of the required heating surface, and have been able to maintain operations. This condition has generally resulted in a flue gas temperature in excess of 500° F., which figure is deemed desirable for our conditions. At the same time the increased temperature has resulted in a greater capacity for a given installation. Assuming that 450 square feet of heating surface per t. c. h. will enable the maintaining of a flue gas temperature of 500° F., then, owing to the greater mean temperature difference between the gases and the water in the boiler, when the flue gas temperature rises, the following areas will enable steaming at the same rate:

Temperature Flue Gases	Square Feet Heating Surface	Per Cent
700° F.	283	62.9
650	312	69.2
600	353	78.5
550	395	87.8
500	450	100.0
450	530	117.9
400	676	150.1

The question is, shall we be extravagant with steam in the factory and continually increase the boiler heating surface so as to abstract the last possible heat units from the gases of combustion, and likewise the heating surfaces in the factory so as to utilize all exhaust, striving at the same time for a high CO₂ content, or, shall we economize on steam in the factory, by practicing the extra use of steam, cutting down on the necessary heating surface in heaters, evaporators, and pans, by using higher pressures in the exhaust lines, and, by using less boiler heating surface, obtain a higher rating at a sacrifice in fuel resulting from a higher flue gas temperature? In other words, by using 350 square feet of boiler heating surface per t. c. h., the flue gas temperature would be increased to 604° F., and the evaporation F/A 212° F. per pound of bagasse of 42 per cent moisture would be 2.82 against 3.00 at 500° F., the flue gases having a content of 12 per cent CO₂ in each case, the evaporation per pound of bagasse being 6 per cent less with the higher temperature. A pre-evaporator combination with vapors heating all juices would more than off-set this loss.

Juice Heaters. The maximum capacity in practice, according to Kopke, is sixty pounds of juice per hour per square foot of heating surface, when the juice velocity in tubes is about six feet per second, when the steam pressure in body is four pounds gauge and the juice temperature rise is from 80 to 212° F. This applies to unbaffled heaters. For the baffled type, the capacity is readily 20 per cent in excess of the above. Based on tests and observations the formula for heating surface for baffled heaters has been developed as follows:

$$\text{Sq. Ft. H. S. per T. C. H.} = \frac{R T_a J}{T_m K}$$

where $R = \text{constant} = 10.23$.

$T_a = \text{temperature rise in } ^\circ\text{F}.$

$J = \text{tons of juice per ton of cane (taken at 1.2 for mixed juice and 1.3 for clarified juice).}$

$T_m = \text{the mean temperature difference between juice and steam.}$

$K = \text{decimal figure expressing efficiency of steam with steam at zero gauge as unity. (For each 1 lb. increase or decrease in pressure, increase or decrease this figure 4.4 per cent.)}$

In this formula T_m and K vary with a change in pressure of steam, and as the exhaust pressure in a factory is reduced, the heating surface must be increased in proportion. For example, lowering the exhaust pressure from 8 to 3 pounds gauge will necessitate increasing the heating surface 70 per cent.

For each 1 per cent of mixed juice on cane above or below 120 per cent, increase or decrease heating surface by 0.83 per cent.

Settling Tanks: Standard practice requires 72 cubic feet per t. c. h. but does not state whether this is to be in three, twelve or twenty tanks, for intermittent settling. Calculation will show that for a given capacity, the greater number of tanks will result in the longest time of settling. Assuming that the time lost, or not available for settling, is equal to 150 per cent of the time required for filling (the additional 50 per cent being required for withdrawing the last clear juices, settlings and scums), then each of the following combinations will give 102 minutes of settling time:

100 cubic feet per t. c. h. in 4 units.

90 cubic feet per t. c. h. in 5 units.

80 cubic feet per t. c. h. in 7 units.

72 cubic feet per t. c. h. in 12 units.

From a cost and labor standpoint we would like to limit the station to four tanks, but this requires a larger unit and total capacity. Suppose, for example, that refractory juices necessitate holding one tank longer than the usual permissible period, then it will be held until its next turn comes. This would leave three tanks in service and the available time would be reduced to about 80 minutes. If 90 cubic feet in five tanks were available and one were isolated, the settling time of the remaining four would be reduced from 102 to 92 minutes; if 80 cubic feet in seven tanks were available and one isolated, the time would be reduced to 98 minutes; and if 72 cubic feet in twelve tanks were available one being isolated, the time would be reduced to about 101 minutes. Obviously, the greater the number of tanks, the less will be the effect on the settling of juices if one happens to be withdrawn from service temporarily.

Evaporators: Reference to the various standards indicates that the heating surface required has been increased gradually from 225 to 300 square feet for a quadruple effect, and that for some conditions 350 square feet would be advisable. Calculations indicate that for every pound that the initial pressure is raised above two pounds gauge, the evaporation is increased 12.5 per cent. Decreasing the syrup Brix to 60 from 70 increases the evaporation 11.5 per cent on an average, the increase being greater at lower initial pressures. Decreasing the vacuum in last cell from 26" to 25" will decrease the evaporation 8 per cent on an average, the decrease again being greater at the lower initial pressures.

The table gives the heating surface required under different conditions of initial pressure, syrup density and vacua in last body:

INITIAL PRESSURE GAUGE	26" Vacuum in Last Body		24" Vacuum in Last Body	
	13-70 Brix	13-60 Brix	13-70 Brix	13-60 Brix
2	350	303	431	376
3	314	274	376	333
4	282	249	334	298
5	255	228	302	271
6	234	211	274	247
7	216	196	251	228
8	201	182	232	212
9	187	171	215	197
10	175	161	200	184

The foregoing table indicates to what extent the requirements will vary. For a given syrup density and vacuum in the last body, the only factor which must be considered is the initial pressure, and this can be controlled within certain limits.

For each degree above or below 13 Brix of juice going to evaporator, decrease or increase capacity by 1.4 per cent when evaporating to 70 Brix, and by 1.6 per cent when evaporating to 60 Brix. For each 1 per cent of mixed juice above or below 120 per cent, increase or decrease evaporator capacity by 0.83 per cent.

Vacuum Pump Capacities: For vacuum pans, the following quantities of air must be removed per square foot of heating surface by a central vacuum, when the number of pans served and the temperature of injection water is as indicated:

Number of Pans Served	Temperature of Injection Water—F°.				
	75	80	85	90	95
1	0.40	0.48	0.60	0.79	1.12
2	0.36	0.43	0.54	0.71	1.01
3	0.30	0.36	0.45	0.59	0.84
4	0.24	0.28	0.36	0.47	0.67

For a quadruple effect, the following quantities of air must be removed per t. c. h.:

10.5	12.5	15.0	17.0	29.5
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These figures are based on a vacuum of 27" in a counter current condenser; an evaporation of 20 pounds per square foot in single pans, an average of 18 pounds for two, 15 pounds for three and 12 pounds for four pans; and the evaporation of 1.3 tons of juice at 13 Brix per t. c. h. to 70 Brix at quadruple

effect. The same corrections would be made to pump capacities for a quadruple effect, as for evaporation from a quadruple effect. Since a volumetric efficiency of approximately 67 per cent applies to vacuum pumps under these conditions it will suffice if the figures given are increased 50 per cent. This will give the pump displacement necessary.

Vacuum Pans: Based on an 8-hour cycle for shipping sugar pans and a 16-hour cycle for low grade pans the following capacities are required per t. c. h. when the cane polarization is 14 and gravity purity of syrup varies as below :

	90	88	86	84	82	80	78
Shipping	42.1	41.4	40.8	40.1	39.5	38.7	37.6
Low Grade	12.2	15.6	19.2	22.9	26.8	30.9	35.2
	<hr/>	<hr/>	<hr/>	<hr/>	<hr/>	<hr/>	<hr/>
Total	54.3	57.0	60.0	63.0	66.3	69.6	72.8

For shipping sugar strikes, the time of boiling is controlled by the steam pressure available, by the ratio of heating surface to cubical capacity, and by the efficiency of the heating surface. The quantity of this depends on the amount of evaporation which must be accomplished. In pan work the temperature difference, as a strike progresses, is affected by the density of the massecuite, by hydrostatic head, and possibly by other factors, and transmission is diminished by viscosity and lessened circulation. For ordinary work the mean temperature difference with steam at 3 pounds gauge is 32.8° F., and with steam at 8 pounds gauge, is 49.1° F. The efficiencies of steam at 3 and 8 pounds are 115 per cent and 139 per cent respectively, so that the amount of work done bears the ratio of 1 to 1.76. Evidently, where a ratio of heating surface to capacity of 1.2 to 1, is sufficient, when boiling with exhaust slightly under 3 pounds gauge, a ratio of 0.7 to 1 should be just as effective with steam at 8 pounds gauge. This confirms practice to a certain extent, for with the old Stade calandria pans using comparatively high pressure steam, the ratio of heating surface to capacity was generally less than one-half. Inasmuch as the additional heating surface required to bring the ratio of heating surface to capacity up to unity is a very small part of the cost of a pan installation, it seems advisable to provide for at least as many square feet of heating surface as there are cubic feet of capacity.

Crystallizers: It is evident that crystallizer capacity required, depends upon many factors. The approximate formula: $R P (98 - J) / J$ gives the cubic feet required per T. C. H. where:

$R = \text{a constant} = 184,$
 $P = \text{polarization of cane},$
 $J = \text{gravity purity of syrup},$

and where a crystallizer cycle occupies 13 days, final molasses purity = 36, final massecuite purity = 55, second sugar purity = 80, final massecuite Brix = 99, and allowance of 15 per cent is made for foaming, etc. The capacities required are as follows:

Cane Polarization	Syrup Gravity Purity			
	90	85	80	75
10	164	281	414	564
12	196	338	496	676
14	229	394	579	790
16	266	450	661	902

The approximate figure of 400 cubic feet, now used, corresponds to a polarization of 14 and a syrup purity of 84.8. A more exact formula has been developed which reads as follows:

$$\text{Cu. Ft. per T. C. H.} = \frac{3 \text{ PDH} \times (\text{S} - \text{J}) (\text{s} - \text{M})}{\text{J} \times (\text{s} - \text{j}) (\text{S} - \text{M})}$$

in which P = cane polarization,

D = number of days in crystallizer cycle (including time for filling, emptying and cleaning),

H = number of hours factory grinds per week,

S = gravity purity of shipping sugar,

J = gravity purity of syrup,

M = gravity purity of final molasses,

s = gravity purity of second sugar,

j = gravity purity of second massecuite.

The purity of second massecuite will depend upon the method of boiling in the factory. Purity of second sugar will depend upon the density of final massecuite, and upon the number of centrifugals and cycle of operation. Necessary crystallizer cycle will depend upon the individual juices. J varies according to condition of cane, fertilizer used, time of year cane is harvested, etc.

Centrifugals: Allowing a 10-minute cycle for shipping sugars, a 60-minute cycle for low grades, and 6.5 cubic feet per charge when using a 40"x24" machine, the following capacity will be required in machines per t. c. h. when cane polarizes 14:

	Gravity Purity of Syrup						
	90	88	86	84	82	80	78
Shipping Sugar	0.1348	0.1328	0.1308	0.1284	0.1263	0.1239	0.1211
Low Grades	0.1087	0.1375	0.1690	0.2015	0.2355	0.2720	0.3092
Total	0.2435	0.2703	0.2998	0.3299	0.3618	0.3959	0.4303

The corresponding screen area would be:

Shipping Sugar	2.845	2.805	2.760	2.710	2.666	2.612	2.555
Low Grades	2.292	2.901	3.568	4.250	4.970	5.745	6.530
Total	5.137	5.706	6.328	6.960	7.636	8.357	9.085

It will be noted that there is a very close agreement between standard and theoretical for 82 purity syrup and 14 polarization in cane.

The foregoing is an attempt to present standards for certain of our cane sugar factory equipment which can be adopted and used in comparing the equipment of factories handling cane juices of very different characteristics.

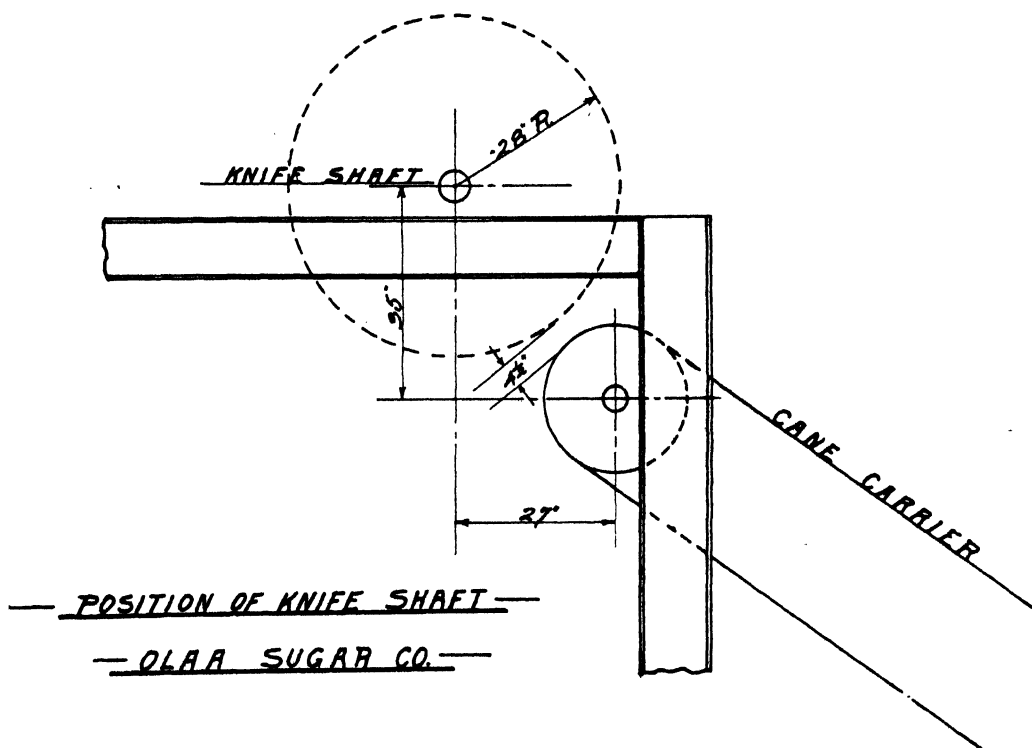
Mill Equipment*

BY G. H. W. BARNHART.

As Chairman of the Committee on Mill Equipment. I have the following report to present to the Association of Hawaiian Sugar Technologists. Replies to a questionnaire sent out at a rather late date have been very encouraging and representative.

George Duncan, of Olaa, writes as follows regarding a set of revolving knives on which he has been working for some time:

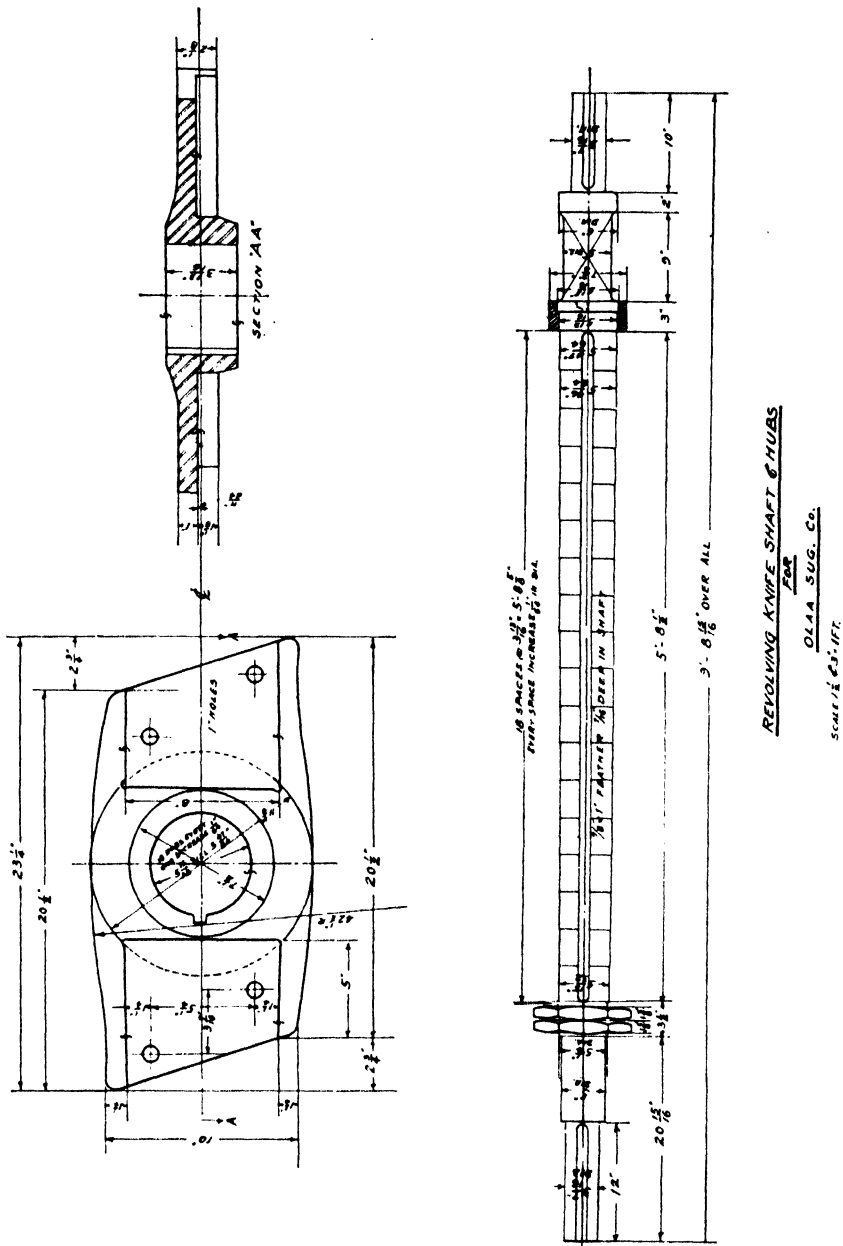
Before this installation we were troubled very much with both our revolving knives and hubs breaking and causing considerable damage to the first mill rolls. As we have no crusher at Olaa, the cane has to be cut very short so as to eliminate trouble at the shredder. As will be seen from this sketch, although the tips of



the knives are $4\frac{1}{2}$ " from the carrier, the cane is cut as short, or shorter, than if the knives were placed directly over the carrier. To eliminate excessive strain on the knives and hubs, a change in construction was necessary. The sketch shows the hub and shaft of the new arrangement. The part of the hub into which the knife is inserted is tapered, the bolt holes being drilled 1" in diameter. The knife is carefully machined to fit the hub, but the bolt holes are drilled $1\frac{1}{8}$ " diameter. When the knife is placed in the hub it is driven outward by a steel wedge until it is practically solid in the hub. The wedge is left to hold the knife in place, and is kept from falling out by a $\frac{1}{2}$ " steel plate, which fits over it and into the knife recess. This plate serves the purpose of holding the wedge in position, supports the knife on the side opposite the hub proper, and prevents the hub from being worn away by the action of the cane coming into contact with it.

*Presented at the Second Annual Meeting of the Association of Hawaiian Sugar Technologists, Honolulu, October 22, 1923.

Since this installation our revolving knife trouble has been about eliminated.



A new crusher feeder has been in use at Pioneer Mill during the past year and a half. This was developed by Chief Engineer Edmund Daniels, out of a caterpillar crank-shaft which was made to operate three arms, each having two cross-arms which traveled upward under the crusher chute and on the return movement engaged the cane in a positive feed. This device was found to be far more satisfactory than the usual star or finger pusher. The crank shaft was made to revolve 10 times to each 3 of the crusher roll.

More and more of the factories are finding it advantageous to separate the crusher and first mill, owing to the impossibility of obtaining a good feed when handling canes, some of which are hard and others soft. Makaweli plans the

installation, in the near future, of a separate engine to drive the crusher and cane carrier. A further improvement at this factory is the deepening of the cane carrier pit, and lowering the carrier so that the cane unloaded from the cars will tend to distribute itself and pack on the carrier, producing a more even and regular feed at the crusher.

Improvements inaugurated in 1919 at Waipahu were not entirely effective until the 1923 crop was taken off, on account of the strike in 1920 and the labor shortage. Both trains now consist of a set of knives, Krajewski crusher, Searby Shredder and 12-roller mill. Comparisons of records while making the installations of the new equipment indicate the Searby Shredder to be responsible for an increase of 1-1.25 per cent in extraction.

The installation of Meinecke intermediate carriers at Ewa has been reported as eliminating practically all delays due to breakage of slats and chain. Ramsay macerating scrapers, while satisfactory in effecting a better absorption of maceration water, are still objected to on account of the large amount of bagasse which must be cleaned out by hand when the mill has shut down.

Secondary strainers, of which there are two generally efficient types in use, are being thoroughly covered by another committee.

A satisfactory substitute has apparently been found for the objectionable juice strainers which, up to the present time, have been a necessary evil in the mill. This substitute is the Unstrained Juice Pump, so named because it handles the combined juice and cush-cush from the mill without its having first been passed through a screen to separate the cush-cush. Open runner centrifugal pumps, screw pumps, air and steam ejector lifts have been used in an attempt to solve this difficulty without satisfactory results. Besides causing the scrapping of the most objectionable piece of equipment from a factory standpoint, the Unstrained Juice Pump should enable a more efficient use of the dilution applied, since a considerable portion of the last mill juice is now "entrained" by the cush-cush from this mill and others in the train and carried back to the first mill without having done any useful work whatever. The trial at Waipahu, where one of these pumps handles the juices from the last two mills of "A" train, was successful. A perforated apron distributor with revolving wooden slats was used for returning the maceration juice and cush-cush over the intermediate carrier.

Most of the factory operators are now aware of the difficulties resulting from the use of feed water, for boilers, which has not been properly treated. Oil, and other foreign matter in steam, has been found to be at the bottom of the majority of the troubles in boilers, boiler tubes, and equipment using this "impure" steam. Feedwater filtering apparatus and oil separators are gradually being installed to eliminate as much as possible of the foreign matter in exhaust steam.

Copper and brass piping and fittings for mill juices are bound to come into general use. The high cost of labor and material for replacing these lines each season, with many cases of inter-season changes, are demonstrating the wisdom of the installation of these lines even though the first cost may be high. The same applies to monel metal cloth for screens.

Three factories have installed high speed vacuum pumps of the Ingersoll-Rand type during the past year. Wherever installed, these pumps are doing good

work, maintaining the necessary high vacuum with a minimum of steam consumption. Some of the smaller factories have found it advantageous to install sugar bins large enough to hold the night sugar, all of the bagging being done by the day shift. Other factories have attained the same result by retaining all night massecuite in special crystallizers, drying and bagging being done only by the day shift. The saving in labor in either case is obvious.

The demand for a higher purity second sugar, and a lower purity final molasses, together with the unusually low syrup purities during the last four seasons has given impetus to the installation of more crystallizer and centrifugal capacity. Lihue has increased its crystallizer 33 per cent, its centrifugal capacity 40 per cent, and a molasses purity of 34.96 for 1923 speaks well for the additional equipment. Kekaha has replaced a considerable number of small tanks and coolers with 16 - 800 cu. ft. crystallizers, the new installation showing a great improvement over the old cooler system in labor, efficiency and technique. Wailuku is installing 6 U-shaped crystallizers. Makaweli reports the addition of 6 - 40" W. D. MacIntosh centrifugals with dischargers. As was usual with a labor saving device, the operators did not at first take kindly to the dischargers, but since using them and becoming reconciled to them, they would not do without them now. These dischargers are time-saving as well as being easier on the men. Wailuku Sugar Company also reports the addition of 6-40" machines.

Olaa's installation of a 45-ton pan with 1800 sq. ft. of heating surface, has rounded out the factory equipment so that it can handle all the cane as it comes and still maintain a satisfactory grain in shipping sugars. A 35-ton calandria pan is going in at Wailuku.

A high speed 20"x32" Nordberg-Todd Poppit Valve Uniflow Engine connected direct to a 300 k.w. A. C. Generator for Wailuku Sugar Company, emphasizes the breaking away from the generally accepted practice of installing turbo-generators for supplying electric power for mills. A similar installation made at Waimanalo was in use during the 1923 crop. While no figures are at hand, it is understood that the steam consumption of the uniflow engine is appreciably lower than that of a turbine or the Corliss engine, and this installation fits in very well where it is desired to cut down on quantity of exhaust steam produced.

The installation of a 175 H.P. motor connected direct to a Cameron 4-Stage centrifugal pump for Wailuku, is also mentioned for the coming crop. While its function is not mentioned, it is hazarded that the water is for driving water-driven centrifugals.

The above completes the information received covering new equipment already installed or being installed.

Among the devices to make the path of the operator an easier one may be mentioned the following:

Safety device on Crusher: A simple electric gong alarm was rigged on the top roll bearing of the primary crusher at Wailuku, so that when the top roll rose above normal feed level a circuit was closed that rang the gong. This warned the man at the cane carrier, and the mill crew, that iron, or other foreign material,

was going through the crusher. This reliable and prompt warning enabled the stopping of the mill before the iron could get to it and do any damage.

Hinged Slats in Cane Carrier: Owing to fine bits of cane and trash packing together in the cane carrier roller chain so that the rollers could not function, it was found, at Wailuku, that hinging two slats at equal distances apart on the carrier so that they would hang when on the bottom travel, permitted the fine particles to drop out at the lower end of the carrier so that no further packing was experienced.

The two slats swing back into place as the carrier's flight, of which they were a part, started over the bottom sprockets on the upward travel.

Continuous Liming Device: C. J. Fleener, of Waipahu, writes that a continuous liming device, perfected at Waipahu, was described in the *Hawaiian Planters' Record* for July, 1923. This is, undoubtedly, the simplest and best liming apparatus on the market.

Mud Stirrers: Many factories are finding it difficult to form a press cake after passing the mill juices through a 100-mesh screen. Kahuku has demonstrated for its own condition, that sufficient liming of the settlings will enable the formation of a perfect cake. It is quite probable that the main difficulty lies in the uneven liming of the settlings. Waipahu is installing two mud tanks which will take the place of the usual "blow up" tanks. In each of these the impeller of a discarded pump will be rotated to insure a perfect distribution of the lime added. The tanks are cylindrical in shape and are arranged with baffles and a central downtake, so that the course of the settlings and lime, while mixing, will be up the walls of the tank and down the center well to the impeller. The baffles are included to prevent the formation of a "vortex" which would retard the rate of mixing.

Koloa reports the use of "sour molasses" and compressed air for "boiling out" evaporators during the 1923 crop, with a saving of 50 per cent in the cost of cleaning. One of the low-grade tanks was fitted up to act as a fermenting tank and the liquor was drawn in through a 3" line by vacuum. Compressed air was admitted through the evaporator doors by means of conveniently arranged 1/2" pipes. An alteration and extension to the sugar bag conveyor now permits the loading of bagged sugar on the cars with a minimum of labor.

Lihue reports that it was customary to boil low grade strikes to 99 brix or denser, prior to 1923, but that due to the long time required in discharging and to the necessity for dilution later on, it was found advisable to boil to 97 only. This speeded up the discharge from the pans, the massecuite handled more easily, and drying was made possible without the addition of any water. Instead of a raise in purity being noted, a drop of a full point was obtained.

James Donald, of Kekaha Sugar Company, writes as follows:

Our most baffling problem, and one we have never solved, is to obtain accurate weights of cane and juice, and samples of these, particularly cane, which are truly representative of the whole. Calculating from juice back to cane, and vice versa, the results seldom agree and are frequently so divergent as to throw doubt on the whole factory control.

An important factor in this state of affairs is the personal one, the reliability of the operator, where the scales are not automatic. As compared with the class of labor we had a few years ago, the men now available show an exasperating indifference to the quality

of their work, and are concerned only in filling in their time somehow. An automatic counter is not of much assistance, and some device or system is needed which will keep a check on the work of the weighers. In regard to the juice weights, I am inclined to believe that a V-notch, or other type of measuring weir with accurate recording and sampling arrangements, would yield more reliable weights than scales, although I cannot speak from experience.

Another important factor is the constantly changing quantity and *nature* of the foreign matter in the cane cars.

It seems hopeless to attempt to arrive at the quantity of "trash" (which includes soil, stones, sticks, dead cane, diseased and rotten cane, rat- and borer-eaten cane, green leaves, dead leaves, etc.) by stripping an occasional car, and the cost of stripping a sufficient proportion of cars to yield a useful correction is prohibitive in these days of scarce, expensive, and inefficient labor. It has been suggested from time to time in the past to weigh the bagasse, and I believe that this question should now be taken up seriously and thrashed out to one conclusion or another. This would give us another check on cane weights and juice weights.

An even better check would be the weighing, or measuring by accurate recording apparatus, of the syrup. This should be done in any case, and if the mixed juice weights are reliable it will be a potent factor in localizing the undetermined losses.

Mr. Giacommetti writes very briefly that the most perplexing problem at Olaa is the prevention of the formation of false grain after the massecuites have left the pans, thus preventing a satisfactory "exhaustion" of final molasses.

The problem of driving a battery of centrifugals by a Corliss engine, and of operating the engine at a speed which was economical of steam, was one which confronted A. G. Barker of Honokaa at the end of the 1923 crop. With the pressure in the boiling house reduced to 70 lbs., and the speed of centrifugals fixed, the problem was one of determining the speed at which the engine would deliver the required horsepower and still be economical of steam, and then arranging the pulley ratios so that the centrifugals would operate at the required speed.

At a speed of 46 r.p.m. the engine delivered 105 h.p. and "failed to cut-off for at least 50 per cent of the time." The operation was very irregular at times, due to "hunting", and the steam consumption was out of proportion to the power delivered. A rough rule for cane sugar factory practice is that the m.e.p. at which the steam consumption will be a minimum is about 40 per cent of the throttle pressure. Applying this, and taking into account material on hand, an engine speed of 65.5 r.p.m. was adopted. "At this engine speed there will be available 42 per cent more power than at 46 r.p.m.; the operation will be more regular, due to the engine cutting-off at all times during normal operation, and the consumption of steam will be much less."

Electrification*

By H. G. PURCELL

Cane sugar factories resemble other industrial plants, especially those which generate their own power and use steam in the process of manufacture. Therefore, the same problem confronts the executive, that is, the simplest method of obtaining the finished product with the least expense.

Concentration of power generation in one plant close to the boiler-room is, in itself, a considerable measure of economy, in that power is generated on a more efficient basis in a large unit and the expense and heat losses incidental to long steam lines is avoided.

With electric drive it is possible to effect economies in building construction due to the comparatively light weight of motors, the small space used and the ease of running electric power circuits to any part of the mill. Machines may be located exactly where they are best suited to the process of manufacture, without regard to the question of drive, and attendance can be reduced to a minimum, as control devices automatically protect the motors and the machines they drive.

Besides performing that part of the work for which it is designed, the machinery of a sugar factory also acts as a reducing valve to supply steam to the boiling-house at the proper pressure, and the simplest method of performing this part of the cycle is the most desirable.

The steam consumption of mill engines and other large units is usually quite satisfactory, but direct-acting steam pumps and small steam engines are inefficient, even when in the best mechanical condition. A duplex pump uses from six to ten times as much steam per horsepower per hour as a Corliss engine or steam turbine.

The electrical equipment of a sugar mill may be divided into two parts, the power station and the factory.

The usual power house installation consists of one or more turbo-generators ranging in size from 300 to 1,500 KW., supplying 3 phase current at 440 volts and 60 cycles. While the turbine seems to be the most popular type of prime mover, Corliss engines are also used and one plantation is installing a Uniflow engine. In a series of articles in *Power*, not long ago, S. H. Mortensen of the Allis Chalmers Co., compared turbine-driven and engine-driven generators, referring especially to Corliss engines in sizes most suitable for sugar mill work. The principle advantages of engine-driven units are their simple design, with easy access to all parts; large slow-moving bearings which are easily lubricated; good ventilation; and low peripheral speeds which tend to reduce collector ring trouble. The advantages of turbo-alternators are the small space required; high efficiency and close regulation, being especially adapted to operating in parallel with other machines, and for supplying current to synchronous motors.

* Presented at the Second Annual Meeting of the Association of Hawaiian Sugar Technologists, Honolulu, October 22, 1923.

Under conditions found in the average mill there is not a great difference in the economy of the three types of prime mover previously mentioned. Using saturated steam at 125 lbs. gauge pressure, and with 4 lbs. back pressure the water rate of a Corliss engine is 26 to 28 lbs. per horsepower per hour, steam turbine 23 to 25, and Uniflow engine 22 lbs. The following figures were taken from a test of a Uniflow engine at the Hoover Vacuum Sweeper Co.:

Steam pressure	140	lbs.
Superheat	100	deg.
R. P. M.....	200	
Back pressure.....	1.9	lbs.
Steam consumption	19	lbs. per h. p. hr.

With saturated steam and more back pressure, the water rate of this engine would undoubtedly be much higher.

In Hawaiian sugar mills the application of motors has not been extended to the crushing plant as it has in Cuba, but they are to be found in most of the other stations throughout the factory, operating conveyors, mixers, pumps, etc.

The importance of properly applying motors and motor control to pumps cannot be appreciated without realizing the dependence of the sugar factory upon this particular type of apparatus. The problem of selecting a motor for a specific pumping application involves careful consideration of the starting and running characteristics of the pump, and the service required.

Owing to the construction of the plunger pump, with tightly packed stuffing boxes and sliding pistons, the initial breakaway torque may equal 125 to 250 per cent of normal full load torque, depending on the mechanical condition of the pump. Immediately upon starting, the pump delivers full capacity per stroke, with the result that full load torque is required for the remainder of the starting period unless the pump is equipped with a by-pass or some means of relieving the pressure until the motor is up to speed.

The running characteristics of this type of pump are simple. A positive amount of water is delivered with each stroke, and the power requirements vary directly with the speed or pressure.

The action of a rotary pump resembles that of a multi-cylinder reciprocating pump, except that there is less friction and the starting torque is much lower.

The centrifugal pump differs from the two foregoing types in both starting and running characteristics. The average centrifugal pump requires about 30 per cent of full load torque at starting, and if the discharge valve is left closed during the starting period, only 50 to 60 per cent of full load torque is required when the motor reaches full speed.

The following general rules apply to centrifugal pumps:

1. The head varies as the square of the speed.
2. The quantity varies directly with the speed.
3. The horsepower varies as the cube of the speed.

With alternating current, the following capacities and types of motors are recommended for the different kinds of pumps:

For plunger pumps, squirrel-cage motors up to 5 h. p., as they can be thrown directly on the line. For larger sizes, wound-rotor motors should be used as

they will develop adequate starting torque without drawing excessive line current.

For rotary pumps, squirrel-cage motors are frequently used in sizes up to 50 h. p.

For centrifugal pumps, it is permissible to use squirrel-cage motors up to 500 h. p. For installations requiring constant-speed motors of 75 h. p. or over, the synchronous type of machine is often used because of the power-factor correction possible, even though it draws as much starting power as a squirrel-cage motor.

This is an important point, especially in a plant where the motors are not always fully loaded. Low power factor is due to lagging current drawn from the line by inductive loads, such as induction motors, arc lamps, etc., and its disadvantages are generally known to power users.

Improvement in power factor can be effected by the application of a synchronous machine which would operate as a power factor correcting motor, that is, part of the input would be used for energy and part for furnishing leading current to the line. The capacity of the motor and its location in the factory would be determined by local conditions.

Unloader	10 h. p. motor
Unloader and Car Haul.	20 " "
Shredder	300 " "
Lillie Evaporator (quadruple).	100 " "
Vacuum Pump (17x10 twin).	30 " "
Maceration Pumps	3 " "
Standard Drain Pumps.	2 " "
Knives	75 to 100 h. p. motor
Mill Pumps	75 to 100 " "
Juice Pumps	10 to 25 " "
Bag Washer	10 to 15 " "
Crystallizers	10 to 15 " "
Centrifugals—	
40" Machines (8).	100 h. p. motor
30" " (16) Low Grade.	50 " "
30" " (12) " "	30 " "
30" " (21) " "	25 " "
30" " (8) " "	15 " "

During the grinding season this year, time element relays, which ring a bell at the crusher station if either knife motor becomes overloaded, were installed in the motor controls on both knife sets.

This warning enables the operator to slow down the cane-carrier in time to avoid jamming the knives and stalling the motor. Since this system has been adopted, there has been a substantial increase in cane tonnage and no stops to clear the knives.

Report of the Committee on Grooving¹

By O. R. OLSEN

As chairman of the Committee on Grooving, I respectfully submit the following:

I addressed letters and questions to twenty mill engineers, and received but six replies, which are incorporated in this report.

J. W. Carmichael, of Hawaiian Sugar Co.:

I don't know that I have very much to say on grooving that is new, unless it is that I believe in coarse grooving for the first and second mills, and fine grooving for the third and fourth mills, say 7 grooves to the inch. This arrangement has worked satisfactorily here, both in extraction, moisture, and a closer setting of rollers.

One other thing I might mention is in connection with the juice grooves of feed and back rollers, and that is to have them straddle. In other words, the first groove on the feed roller would be 2" from the end, while the first groove on the back roller would be 3" from the end, with the following grooves spaced 2" apart.

E. Daniels, of Pioneer Mill Co.:

We have no juice grooves on the back roller of our first mill, but the grooves are deep enough to drain the juice without the juice grooves. This method has been applied as the Puunene standard.

In my opinion, the coarse grooving on feed rollers with diagonal grooves, feed better with close mill setting, as it avoids regrooving during the season.

R. E. Hughes, of Puunene Mill:

To establish some sort of a standard here, in both the Messchaert and surface grooving of rollers, the grooving now in use was decided upon several years ago, after considerable experimental work had been done to determine just what would be the best groove to suit our conditions.

Before the introduction of the Messchaert groove and the Searby Shredder, the practice of changing the surface grooving of this, that and the other mill, was common, with very little noticeable change in the quality of the work. Our standard was arrived at gradually, and completed early in the year 1918. Since that time we have made no changes in the grooving, following as closely as possible our standard, which is as follows:

MILLS OPERATING WITH SEARBY SHREDDERS

First Mills: All first mill rollers are grooved to mesh, pitch of surface grooves $\frac{3}{4}$ ", feed roller Messchaert grooved $2\frac{1}{4}$ " pitch, when new $9/32$ " wide and $2\frac{1}{4}$ " deep. No Messchaert groove scrapers are used on the returner bars. One set of scrapers at the bottom of the roller. No Messchaert grooves in the discharge rollers.

Second Mills: Feed rollers are grooved $\frac{3}{4}$ " pitch, Messchaert grooved $2\frac{1}{4}$ " pitch, $9/32$ " wide by $2\frac{1}{4}$ " deep. One set of Messchaert scrapers are fitted under this roller. Top roller surface grooved 8 to the inch. Discharge rollers surface grooved 8 to the inch. Messchaert grooved 2" pitch, $9/32$ " wide by $1\frac{1}{4}$ " deep. One set of scrapers fitted to, and resting on lower blade of the Ramsay scraper, with a second set below the roller.

¹ Presented at the Second Annual Meeting of the Association of Hawaiian Sugar Technologists, Honolulu, October 22, 1923.

Third Mills: Feed and top rollers grooved same as second mill. Discharge roller surface grooved 8 to the inch. Messchaert grooved 4" pitch, 9/32" wide and 1 3/4" deep. Scrapers arranged same as second mill.

Fourth Mills: Feed rollers grooved same as second mill. Top same as second mill. Discharge rollers surface grooved 8 to the inch. Messchaert grooves 2" pitch, 9/32" wide, 1 3/4" deep. Two sets of Messchaert scrapers are fitted below the Ramsay scraper. All bagasse from these two sets is returned to the same mill in a dry condition by scroll conveyor.

Operating with this arrangement of grooving, we have had excellent results in extraction, low moisture in the final bagasse, and no difficulties with the feeding of the mills.

To insure a maximum efficiency from the Messchaert grooves, they should be deep enough to allow for rapid and unobstructed drainage of the juice, yet not so deep as to weaken or shorten the life of the roller. If the bagasse is allowed to press down to the bottom of the groove, the mill might do as well without any Messchaert grooves. The same can be said of the groove when it is not scraped clean with each revolution of the rollers.

Our first mill rollers were grooved with the 3/4" pitch groove soon after the installation of the Searby shredders. These take hold of the shredded cane and feed under all conditions or rates of grinding, and allow a very fine drainage way for the expressed juices.

Our last step in completing our standardization of the roller grooves, consisted of the fitting up of all the mills with a feed roller of 3/4" pitch. This change improved the feeding of the mills to such an extent that we were able to slow down the mills, thereby operating with a heavier blanket of cane and obtaining a higher extraction.

A 3/4" pitch grooved roller, with Messchaert grooves of 2 1/4" inch pitch, when placed in the fourth mill of a twelve-roller train as a feed roller, will tend to reduce the moisture in the final bagasse.

The surface of these coarse grooved feed rollers improves as the grinding proceeds, the juice action tending to rough up the surface, so that it soon becomes a mass of very small teeth.

It has been our experience that wear and breakage with this groove is no greater than with any other.

A good percentage of large pieces of iron, such as car pins and links which find their way into the mill, are removed at the crushers, as the hydraulic accumulators indicate immediately the presence of any hard material. If any does get by, it is heard passing through the shredder, and an effort is made to remove it before entering the mill rollers; not all, by any means, being recovered, a fact that is substantiated by the condition of some of the rollers at the end of a season.

We have made some very interesting, and from all appearances successful, acetylene repairs to some of our rollers that were broken down on the side of the Messchaert groove, or broken away at the extreme end of the roller. The broken down parts were at first quickly heated with a large oil torch, and the space welded or filled in with Tobin Bronze. The weld in every case, from all appearances, after machining and grooving is a good one. Bronze was used so that it would not be necessary to heat the roller to a very high temperature, thereby eliminating to some extent the chances of cracking the roller, as it is welded while on the shaft.

We do not expect the bronze to resist wear as well as the iron, but we do look for less Messchaert groove scraper trouble, and thereby add one more little item that should make for a smoother and more efficient operating mill.

In answer to questions relative to juice grooves in first mill feed roller, and juice grooves in other rollers of various pitches, the following replies were received:

W. A. Kinney, of Waialua Agricultural Co.:

During the 1923 crop we did use juice grooving in the feed roller of the first mill. The juice grooves in the other rollers are of various pitches, due more or less to old rollers.

We have standardized on 25 juice grooves 3/16" wide by 1 3/4" deep. The grooving of the first and second mills for the 1923 crop was changed.

First mill: Feed rollers—3/4" pitch. Top roller—3/8" pitch. Back roller—3/8" pitch.

Second mill: Feed roller—3/8" pitch. Top roller—3/4" pitch. Back roller—3/4" pitch.

This has proved very satisfactory. We are using the original style of juice groove scrapers.

Iron seldom gets beyond the crusher, but of course when it does, it plays havoc with our juice grooves. A hydraulic alarm is used on the crusher.

J. L. Renton, of Ezra Plantation Co.:

It is our intention to install the 3/4" pitch feed steel roller in the second mill this off-season for trial next crop.

We are gradually changing the pitch of our top and back roller grooving from 3/8" to 3/16" pitch. Before the advent of the Messchaert grooving, I believed the coarse grooving a help, both in feeding and juice extraction, but with the Messchaert grooves we have gradually gone back to a finer grooving with equal results.

George Duncan, of Olaa Sugar Co.:

Previous to the campaign just finished, all of our rollers were grooved 6 to the inch. At the end of last year it was decided to groove the feed rollers 3/4" pitch, which grooving we used all this year. Very little, if any, advantage was observed from the use of them. They were very easily damaged by tramp iron, consequently the turner bar grooves were also damaged. This resulted in frequent breakage of the turner bar hook bolts. The juice grooves also wore away at the sides very quickly, this probably being caused by the bagasse becoming wedged tighter into them, helped by the wide 3/4" groove at the top.

This year we intend to change the pitch to 3/8". Several years ago we used this size grooving and very little trouble was experienced, even from iron getting into the mill.

I think large grooves, i.e., about 3/4" pitch, are detrimental to the roller. The only advantage to be gained from them as far as I can find, is heavy feeding, but this can be quite as easily obtained from grooves about 3/8" pitch. The life of the roller is considerably shortened by the large grooves, and every plantation is not in a position to purchase new ones every two or three years. I think, therefore, before recommending such coarse grooving that due consideration should be given to local conditions.

At Lihue mill, the writer wishes to say that a coarse grooved 3/4" pitch feed roller was installed in the first mill in 1919, and this roller is still in operation, but as feed roller in the second mill, and we expect at least a couple of years more service from it. The rest of the rollers were of fine grooving, and we experienced considerable trouble in feeding.

For the 1922 crop, we grooved the feed rollers of mills No. 2, 3 and 4 with 3/8" pitch grooves, and obtained better results in feeding.

For the 1923 crop, we equipped the first mill with 3/4" pitch grooved rollers, and the second and third mills with feed rollers of 3/4" pitch grooving. As we had no suitable roller for coarse grooving, at that time, for the fourth mill, we retained the 3/8" pitch feed roller. All the other rollers in mills No. 2, 3 and 4 were grooved 7 to the inch. Our feed troubles ended in the mills equipped with coarse grooved rollers, but we continued having trouble in feeding the fourth mill.

This year we are installing a 3/4" pitch grooved feed roller in the fourth mill. Iron, in the shape of car links, pins, etc., find its way into the mill, and is first noticed when passing through the shredder. An attempt is made to get it before it enters the rollers, but very seldom are we fortunate enough to get it before the

first mill. We generally find it between the first and second mills, but at times some gets by.

We have had no trouble with the returner bars or hook bolts breaking, through iron entering the mill.

The grooving on the first mill rollers was considerably damaged by iron, and we were obliged to regroove the top roller once during the crop.

A single set of juice groove scrapers is used on all the feed rollers, with no scrapers on the returner bar toes. The back rollers are equipped with juice groove scrapers resting on the lower Ramsey scraper, and one set below the roller, with the exception of the fourth mill, which has two sets of scrapers below the roller scraper.

In conclusion, I wish to thank the following gentlemen for data furnished of their respective mills: E. Daniels, R. E. Hughes, J. W. Carmichael, Geo. Duncan, J. L. Renton and W. A. Kinney.

Machine Shop Equipment*

BY J. L. RENTON

This is a new subject and one that can be made of much interest to the engineers.

Buildings: There are several modern machine shop buildings on the various plantations, such as those at H. C. & S., Paia, Lihue, Oahu, Ewa, and possibly others with which I am not acquainted. The accurate work required from a shop demands a well lighted building, and this feature has been mastered and excellent results obtained by the installation of sash and skylight. Mr. Taylor of H. C. & S. says he thinks a shop in this country should never be built with skylights as the glare is too bright and warm.

The writer is of the opinion that the metal sash without skylights is the best, as sufficient light is admitted and the air that is available by opening the sash makes for an airy and cool work room. As far as light alone is concerned, the skylight arrangement at Oahu Sugar Co. cannot be improved, and ventilation is obtained by large doors and some sash.

Lihue Plantation leads all others in the location of its shop, which is served by the same electric crane which covers the mill. The transfer of heavy mill machinery to the shop is a simple matter, and much time and labor is saved.

All of the five above-mentioned shops have fully electrified cranes.

Tools: No set list of tools for plantation requirements can be made though there are some tools that all plantation shops must have. It is only the larger plantations that can branch out into a more or less special tool instead of duplicating what is already on hand. No discussion of lathes, drill presses, shapers,

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pipe machines, or grinders will be attempted, as all plantations have all of them, excepting some which probably substitute a planer for the shaper.

The advantages of the open side planer for plantation use are evident when most of the new planers installed are of this construction.

Key-seaters, slotters and heavy presses are necessary where rollers are assembled. Several plantations have small hydraulic presses. An arbor press which would soon pay for itself, is very inexpensive and powerful, being useful even in a small shop.

Present day pipe machines will thread bolts, easily making a bolt machine unnecessary except on the larger plantations.

All shops, no matter how small, should have a power-driven saw, as it is a labor saver and in use most of the time.

The power-driven punching and shearing machine is a necessity to all large shops.

Mr. Bourne, shop foreman at Ewa, reports that he does not know how we ever got along without the power punch and shear, and that one should be on every plantation regardless of size. This machine has been in constant use since erection, on practically only repairs necessary to upkeep of equipment, and no new work done. This work would have had to be done somehow and indicates a great saving in time and labor.

Several shops report a milling machine. At the new shop at Ewa Plantation, a horizontal boring, milling and drilling machine was recently installed, and is being watched with considerable interest. Mr. Bourne reports: "I believe this to be the only one of its kind on a plantation in the territory. Its worth as a general utility tool on plantation work was demonstrated the first month it was in operation. It has been put to use boring cylinders, boring journal boxes of all kinds, including mill roller journals and main engine bearings, besides milling all key-ways. It is extremely easy to set up, with adjustable power feeds and quick return in all directions, all of which is easily handled with accuracy and speed."

Plate rollers are useful, especially to the irrigated plantations.

Mr. Taylor of H. C. & S. reports: "We have just completed a pipe 39" in diameter and over two hundred feet long made of 3/16" plate, all of which was electrically welded. When we tested the pipe we didn't have a single leak. We saved a great deal of time, labor, and material on this job."

Most plantations are equipped with compressed air and the necessary tools, also gas and electric welding outfits. They pay for themselves in labor saved and material reclaimed that would otherwise be lost.

Jigs and Fixtures: This topic can be made intensely interesting to the engineer, as a means of interchanging useful information. There are innumerable like parts made in quantity on the plantations, and when an engineer finds an easier way to make these duplicate parts, the method of so doing would be welcomed by all mill engineers and shop foreman. Such parts as shredder hammers, leveler knives, chain links, scraper toes, etc., are samples of such duplicate parts.

Mr. Olsen reports on grooving rollers and scraper toes as follows:

A little jig of the same principle as the milling machine index head, was worked out here and attached to the feed screw of the roller lathe. It is operated with ratchet and lever, and in changing from one groove to another, the boy pulls out a pin and operates the lever until the proper distance has been reached, when the pin drops in again. We have done away with all the delays of time lost, due to measuring, etc. This jig worked so satisfactorily on our coarse grooving and fine grooving, that I equipped the large shaper and small planer with the same rig, and now I can groove my returner bar toes and scrapers in half the time, and know they will fit the roller grooving when finished.

Mr. Duncan, of Olaa, also has a like jig for grooving returner bar toes in the shaper. He sent in a photo of his shaper machining the jaws of a mill housing, which I am sorry I can not include in this report but have it for those who would be interested in seeing it. I would recommend the following title for the photos: "Where there is a will there is a way."

Brass Foundry: Paia has the largest and probably the best plantation brass foundry in the Islands. With fuel oil and compressed air available, any plantation could build a crucible melting furnace for small brass parts and save money by utilizing the scrap brass available.

Tinsmith Tools: Few plantations report having any but the simplest tinsmith tools. It is wonderful what excellent work is turned out by some of our employees with a soldering iron and a few pieces of scrap. Tools would make the parts more quickly, if not any better, at a saving in labor and time.

Tool Room: Practically all engineers report the same. Bins, shelves, racks or pins for every tool, and a place for every tool. All men drawing tools from the tool room are furnished with checks (or bangos) and deposit one for every tool drawn, in most cases the check being placed in the compartment vacated by the drawn tool. This is as simple and as accurate as any system and works out well. Usually, all tools must be returned to the tool room Saturday night, to be drawn out again if needed.

Two tool rooms report drill grinders, but the writer believes there are others who neglected to report.

Salvage: This department can always pay for itself and the more systematized it becomes the greater will be the returns.

Waialua, Oahu, and Olaa report reclamation warehouses. The writer has visited the one at Oahu Sugar Co., and commends it highly as an example for plantations desiring to install a system of this sort. The entire building (of moderate size) is given over to reclamation of salvage, with a man there continually. The attendant is given other work and when not thus occupied does reclamation work. Bins and boxes are provided for material, through this warehouse.

In conclusion the writer would like to call attention to the matter of "Labor Saving." Under our present conditions this is a topic for serious thought, and if a piece of machinery will save labor it should be considered also in that light.

Electric cranes, arbor presses, power saws, power punches and shears, air tool, gas welding, electric welding, and tinsmith tools have all been mentioned in this report as labor saving devices, and the field has not been half covered.

The scope of this report is very general and leaves the more detailed reports and general discussion for subsequent papers.

Report of the Committee on Juice Preservation

BY L. W. HOWARD

From the small number of replies that I received and the greater number that I did not receive, I am forced to believe that other phases of the sugar industry have been more thoroughly investigated and experimented with the last year than the line upon which I requested information. I am therefore obliged to recapitulate more or less in order to present any report at all.

MILL SANITATION

This is a phase of the subject that has received considerable attention during the last few years, special effort being made to overcome some of the losses that have occurred around the mill, juice strainers, troughs and tanks.

The deterioration of very dilute acid juices, we all know, is very rapid. Its rate of inversion is also increased by the presence of sour, slimy accumulations, invariably found around the mill checks, returner bars, bolts, or other places where unless exceptional care is taken in cleaning the mill, their presence will not be discovered.

We have not, as yet, determined how far a loss can be traced directly to that condition, but there is no doubt that there is a great loss.

Juice pans, troughs, and strainer slats are probably accountable for a great deal of this. A possible remedy would be to replace wooden slats, which become saturated with juice, by slats of angle iron. A fiber or fabric edge could be placed upon the scraping edge of the angle iron.

Usually, the troughs or piping under the juice strainers are in some inaccessible place and are, therefore, seldom if ever, cleaned. Some provision should be made for steaming them thoroughly at regular and frequent intervals.

As an inevitable consequence of the increased efficiency of our present day mills, the engineer of today finds himself facing new problems of sanitation. Our modern mills, with their superior double knifing and shredding, have multiplied the amount of mush to be handled; and, these finer particles finding lodgment among the bolts, joints, and crevices, the problem of perfect cleanliness is rendered correspondingly more difficult.

Mr. Pratt, of Lahaina, Maui, reported a very interesting experience with *Leuconostoc*. It was not due to heavy liming, as it occurred on the way to the juice scales, and not after lime was added. The average of about twenty juice samples, preserved with formalin, showed a decrease in polarization of .32 or slightly over one-half per cent. These were regular samples, and some of them might not have been infected by the *Leuconostoc*.

Experiments made after adding the bacteria to mixed juice showed that there was practically no loss in either the hot or cold juices in the space of 15

* Presented at the Second Annual Meeting of the Association of Hawaiian Sugar Technologists, Honolulu, October 22, 1923.

minutes or half an hour, whether the juices were limed or not. On juice that had stood for three hours, there was considerable loss, greater in hot juices than in cold, and slightly more in alkaline than in acid juice.

Mr. Robbins, of Oahu Sugar Company, reports that they have always felt there was some deterioration in their mill juices before they reached the liming station. One of the causes of this is enlarged mill juice strainers, made imperative by the necessity of separately straining the juices of the third and fourth mills. They are now planning to use a make of juice pump that will enable them to return the juices of these two mills without screening. The only raw juice strained, will then be the mixed juice, and they also hope to eliminate the wooden slats and chains on that strainer.

We are confronted frequently with the problem of accurate analysis of our laboratory samples. Are we not at times deceiving ourselves into thinking that some of our juice analyses are right, when there has been an unobserved, but none the less unmistakable, deterioration taking place?

Mr. Orth, of Ewa, in his answer to my circular letter, enclosed an account of some experiments that he had conducted at the Ewa laboratory with the use of preservatives, for keeping samples without any effect upon sucrose or glucose. I present herein the results of that experiment:

TREATED SAMPLES ANALYZED AFTER 24 HOURS

DRY LEAD ACETATE (Horne's Dry Lead)

Grams per Liter

	Original	12 grams	14 grams	15 grams	16 grams	18 grams
Gravity Purity	85.60	85.42	85.42	85.51	85.51	85.51
Glucose	0.53	0.53	0.53	0.49	0.51	0.51
Glucose Ratio	5.10	5.11	5.11	4.72	4.91	4.91

MERCURIC CHLORIDE

	Original	1 gram	2 grams	3 grams	4 grams	5 grams
Gravity Purity	86.37	85.87	85.99	85.70	86.37	86.37
Glucose	0.61	0.65	0.62	0.59	0.55	0.54
Glucose Ratio	5.50	5.89	5.61	5.36	4.96	4.87

SODIUM BENZOATE

	Original	2 grams	3 grams	5 grams
Gravity Purity	87.19	79.21	83.07	81.87
Glucose	0.44	1.01	.60	.75
Glucose Ratio	4.43	11.19	7.29	8.04

TOLUOL (TOLUENE)

50 cc. Toluol per 1,500 cc. Juice

	As Used	After 24 Hours	After 48 Hours	After 72 Hours
Gravity Purity	82.82	80.14	77.52	74.37
Glucose	0.73	1.07	1.41	1.75
Glucose Ratio	7.93	11.99	16.36	21.08

TOLUOL IN COMBINATION WITH SODIUM BENZOATE AND MERCURIC CHLORIDE

25 cc. Toluol per 1,500 cc. Juice

		Sodium Benzoate	Mercuric Chloride	Sodium Benzoate	Mercuric Chloride
	Orig- inal	3 grams per Liter 24 Hours	3 grams per Liter 24 Hours	3 grams per Liter 48 Hours	3 grams per Liter 48 Hours
Gravity Purity	80.78	76.18	76.30	73.59	75.37
Glucose	0.98	1.13	1.08	1.54	1.10
Glucose Ratio	10.46	12.53	11.65	17.66	12.02

We note that samples treated with varying amounts of Horne's Dry Lead when analyzed after 24 hours showed a very little change. The samples treated with mercuric chloride of varying amounts, show very little change after 24 hours. The samples treated with Sodium Benzoate show a very great difference, which varies with the increased amount of sodium benzoate used.

The use of Toluol (Toluene) also causes a very rapid change after 24 hours, and Toluol in combination with Sodium Benzoate and Mercuric Chloride for a like period is responsible for a rapid change.

The question of juice standing over in settling tanks on week-ends or on long, enforced stops brings out some very interesting data. Oahu Sugar Company uses no preservatives in their left-over juice, but they do overlime and heat it to 180° F. They report practically no loss in purity under this treatment.

Mr. Pratt reports a like method in use at Lahaina, with no drop in purity observed. At Waialua, we have made an analysis of every tank of left-over juice. A sample was obtained from the middle draw-off cock of the settling tanks about an hour after they were filled, and a like sample taken again when the tanks were opened 24 hours later. There was usually a drop of about .8 in purity. The juice that was to remain was overlimed, some formalin added at the liming tank, and the temperature dropped to about 180° F. It has been very satisfactory.

Mr. Hadfield, of the Hilo Sugar Company, adds, as a general rule, 2 or 3 pounds of Carbonate of Soda to 5 tons of raw juice and finds that, although the above quantity is sufficient to keep the juice alkaline until midnight Sunday, the purity drops a point or two.

Mr. Charles Richter reported the use of formalin, at McBryde, which he found usually prevented deterioration. At Kaiwika, where he substituted for a while during this crop, he continued the use of formalin and also overlimed. He advises the addition of formalin before the juice is pumped into the settlers, making possible a more thorough mixing.

Mr. Giacometti, of Olaa, stated that he believed all tanks, pipes, and containers should be properly cleaned once a week and, if necessary, disinfected. We are all agreed that cleanliness is one of the simpler methods of increasing our recovery and of saving further troubles in the processes.

I am submitting a brief statement made by William L. Owen, research bacteriologist of the Louisiana Sugar Experiment Station, regarding a method for the prevention of deterioration of sugar in storage.

This method will eliminate one of the largest economic losses there is in the manufacture of raw sugars, which is the deterioration in storage. It is estimated that the loss per annum on the normal Cuban crop is \$1,500,000.00.

According to Mr. Owen, means have been found for preventing this loss by the inoculation with a certain species of yeast, which acts only on the reducing sugars, producing carbon dioxide and preventing the development of molds, which are the causative agents in producing deterioration. As a result of the action of the yeast on reducing sugars, raw sugars in storage increase in polarization rather than decrease. Mr. Owen is now working out details with a view to the utilization of the method on an industrial scale.

The Miner Laboratories, of Chicago, have reported on a preserving agent that is known as Furfural. The results of their experiments have indicated that the bactericidal action of furfural is comparable with, and the fungicidal actions decidedly superior to, that of formaldehyde. They claim that low concentrations of furfural are not toxic and believe it can be substituted safely and even with decided advantage for formaldehyde in the sugar industry.

I am sure that many of the reports which have been made, or will be presented later at this meeting, will bring out points along the lines of juice preservation, which I have overlooked.

One of our great problems is that of keeping every station in the factory as clean as possible, in order that nothing may enter the process to cause unnecessary inversion, thereby decreasing our recovery or lowering the standard of our product.

A Discussion of the Meaning of the Terms Hydrogen Ion Concentration and P_H Values of Solutions*

BY REGINALD H. KING

During the past decade there has appeared in the literature on sugar manufacture and soil chemistry a term called the pH value of solutions; synonymously with this, a term called the hydrogen ion concentration has been used. Due to the increasing importance being placed upon the reaction, acid or alkaline, of solutions and soil conditions these terms have become exceedingly common and appear in every article. Without a clear and complete understanding of their meaning the essential conclusions to be drawn from experimental data cannot be appreciated or understood. This paper has been written in as elementary a manner as possible in order to clarify any misunderstanding that may exist.

All things must have a beginning; in general their start is in the crude and basic; these terms originated in the elementary principles of chemistry. For a complete exposition it is necessary that the principles of dissociation, chemical reaction, and the fundamental conception of molecular weights be reviewed.

The most elementary, and perhaps the most important, principle to be considered is that of dissociation. By dissociation is meant the behavior of certain substances such as strong acids, bases, and their salts in solution. A salt is a

* Presented at the Second Annual Meeting of the Association of Hawaiian Sugar Technologists, Honolulu, October 22, 1923.

compound resulting from the neutralization of an acid by a base, viz., sodium chloride, calcium chloride, calcium phosphate, etc. An acid, it may be recalled, is a substance having a sour taste and certain clearly defined properties of producing color changes in substances called indicators. A base is a caustic substance generally thought of as the opposite to an acid in its color-changing property. These substances have certain physical characteristics by which they can be identified, but in solution they have entirely different properties.

A soluble salt when placed in water not only dissolves and disappears but undergoes a decomposition—splitting up into its component parts. This decomposition is known as dissociation. Sodium chloride, for example, dissociates into two component parts, viz., sodium and chloride, but they no longer have the usual physical and chemical properties and are therefore known as *ions*, i. e. sodium-ion, chloride-ion. Hydrochloric acid dissociates into hydrogen ions and chloride ions; calcium hydroxide, a base, into calcium ions and hydroxyl ions. From the foregoing it is seen that the term *ion* is a general one. This should be readily appreciated; all the members of a family have a common name by which the group is known. The individuals in that group have different characteristics, therefore a different Christian name. Think of this term *ion* as the name given to the chemical elements in water. Hydrogen ion means the hydrogen from an acid or other source in water.

In order to be able to measure a thing, or quantity, it is necessary that a definite unchangeable unit be established. A dollar is a definite measurement of wealth; the pound, that of a definite quantity by weight of a substance. It is true that the quantity of any substance in a mixture may be expressed as the percentage of the whole. For example: twenty grams of sugar dissolved in eighty grams of water is a twenty per cent sugar solution. These systems of expressing quantities are of no value in chemical work, in that they do not indicate any self-evident idea concerning the quantities capable of reacting. In order to overcome this inexactness, chemists have devised a system based upon the molecular and normal weights of chemical substances.

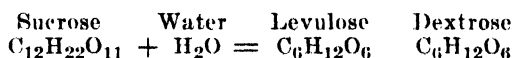
All true chemical substances have what is known as a molecular formula, a molecular weight, and a normal weight. The molecular formula for sucrose is $C_{12}H_{22}O_{11}$. This formula indicates that twelve parts of carbon, twenty-two parts of hydrogen and eleven parts of oxygen have been combined by the life processes of the sugar cane. Hydrochloric acid has the formula HCl ; one part of hydrogen and one part of chlorine have combined to form the acid. These examples may be multiplied, but these few should suffice to illustrate this idea. These formulae not only signify the chemical nature of the substance, but also give the mass or weight of each element in the compound. In this system, the mass of the hydrogen atom has been considered as unity—all other elements in the atomic state are multiples. For example: hydrogen has an atomic weight of one; chlorine 35.46; carbon 12; calcium 40; etc. This conception of formulae and molecular weights is used in the preparation of standard reagents; the term *normal* weight is most frequently encountered. This normal weight is not that of twenty-six grams of sugar used in sugar house practice, but is the amount, by weight, of a substance capable of reacting with one gram of hydrogen.

By the term hydrogen ion concentration is meant the concentration of free hydrogen ion in a solution. Free hydrogen ions in excess of free hydroxyl ions produce a condition known as "acidity". From this definition, then, the term implies a quantity, therefore a measurement; for a purpose of comparison, a scale of measurement. Before it is possible to discuss this hydrogen ion scale a clear understanding of the chemical behavior of water is necessary. ✓

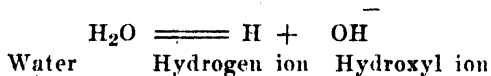
Water has certain well-known physical properties with which everyone is familiar; it has chemical properties not so widely known. By very refined methods of analysis it has been found that pure distilled water consists of very large amounts of undissociated water, chemical formula H_2O , and very small amounts of free hydrogen ions and hydroxyl ions. This fact indicates that water dissociates, that is, it undergoes a decomposition. In order to clearly illustrate this fact, as it is of the utmost importance in the understanding of the hydrogen ion concentration scale, an example will be considered with which nearly everyone is familiar.

Pure sugar, sucrose, under certain conditions can be made to decompose into dextrose and levulose. Consider a gram of pure sucrose, by the use of a small amount of hydrochloric acid a very small amount can be decomposed into levulose, which rotates the plane of polarized light to the left, and dextrose which turns the plane to the right. After a very short time the original sugar will contain small amounts of levulose and dextrose, say about .001 grams of each. This is not strictly true; the reducing sugar equivalent of sucrose is 1.05, but for the purpose of this discussion this can be disregarded.

This decomposition being understood, suppose that one gram molecule of sucrose, 342 grams, be dissolved in one thousand cubic centimeters. This is a normal solution, that is, one gram molecule per liter. To this sugar solution a very small amount of hydrochloric acid is added and within a very short time neutralized. Within this very short time there will have been decomposed, say .000,000.1 gram molecule of sucrose and there will have been formed .000,000.1 gram molecules of levulose and .000,000.1 gram molecules of dextrose. The following equation sums up this reaction:



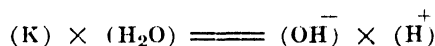
Water, like sucrose, breaks up to a slight degree but its component parts are ions and carry an electric charge



In the case of the sugar solution this decomposition was static. That is, the sucrose had been definitely changed into levulose and dextrose, they do not recombine. In the case of water this decomposition is not static, but dynamic. That is, the component parts recombine; hydrogen ions combine with hydroxyl ions to form undissociated water.

This decomposition and recombination is constant for any given condition of temperature. In order to indicate this constant quantity the letter K can be introduced as meaning a constant denoting the rate. This equation indicates a

definite mathematical relation; its terms can be multiplied, etc. Multiplying and rewriting:



(This equation is a statement of the Mass Law, which requires no explanation in this paper.)

By careful research the values of H^+ and OH^- have been found to be .000,000,1 gram molecules per liter.

Since the concentration of H^+ and OH^- is so small in proportion to the large amount of the undissociated water, H_2O , the undissociated H_2O can be considered equal to 1. Solving:

$$K = \frac{(H^+) \times (OH^-)}{(H_2O)}$$

$$K = \frac{(.000,000,1) \times (.000,000,1)}{1}$$

$$K = .000,000,000,000,01$$

This makes a very unwieldy term to handle in any calculation. In order to simplify, it can be rewritten. Before rewriting, this step should be made clear:

Consider the number.....	.0002
This may be expressed.....	2
	10,000 ⁻
Also as	2
	10x10x10x10

This expression is infinitely more complicated; in order to simplify, the tens can be given negative exponents and placed above the line, that is in the numerator:

$$\frac{1}{10} \text{ becomes } 1 \times 10^{-1}$$

$$\text{the expression .0002 becomes } 2 \times 10^{-4}$$

Using this simplified method of expression K becomes equal to 1×10^{-14}
 Substituting this value of K back in the original equation

$$(H^+) \times (OH^-) = 1 \times 10^{-14}$$

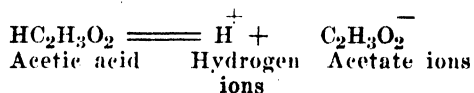
This equation states in words that the product, *not the sum*, of the hydrogen ion and hydroxyl ion concentrations in pure water is equal to .000,000,000,01.

From this equation, based upon the dissociation of water, no matter how concentrated the hydroxyl ions may be, there must remain sufficient hydrogen ions to satisfy this relationship. This fact allows the construction of an acidity-alkalinity scale in which the conditions of solutions can be expressed in terms of hydrogen ions. A solution might be exceedingly alkaline but its condition would

be expressed in terms of hydrogen ion concentration. In this scale a hydrogen ion concentration of 1×10^{-7} indicates neutrality; one of 1×10^{-9} alkalinity; and one of 1×10^{-1} extreme acidity. ✕

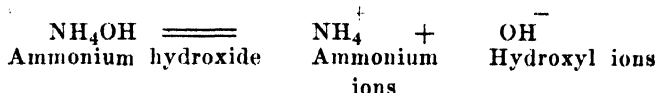
The terms hydrogen ion concentration and acidity have been used rather interchangeably; this should not be done as there exists a marked difference. A value expressing the hydrogen ion concentration of a solution indicates the intensity, one expressing acidity shows the potential or total amount. For example: consider two boilers, one having a five hundred boiler horse-power per hour rating with a gauge pressure of fifty pounds, the other a much smaller one with a gauge pressure of one hundred pounds. The first, with a smaller pressure, is capable of generating a much greater amount of energy than the other with its one hundred per cent greater pressure. Two solutions having an acid reaction may have the same acidity but entirely different hydrogen ion concentrations, or vice versa. Hydrogen ion concentrations may be likened to gauge pressure, and total acidity to available energy. This distinction between degree or intensity of acidity and total acidity may be expressed in the following manner: Intensity of acidity, is the hydrogen ion concentration; total acidity is the total amount of un-ionized acid which is present in a combined form.

The statement "combined form" leads to a discussion of weak electrolytes, i. e., acids, bases, and their salts that dissociate in solution only to a small degree. Acetic acid, a weak electrolyte, dissociates in the following manner:



This dissociation is constant, and is less than two per cent in a normal solution, that is, the amount of acetate ions and hydrogen ions is less than two per cent of the total acetic acid originally present.

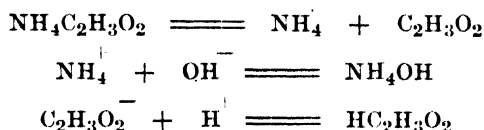
A weak base, such as NH_4OH , dissociates only to about four-tenths of a per cent in a normal solution in the following manner:



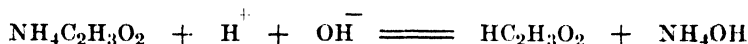
The dissociation of a salt of a weak acid or weak base is exceedingly involved, due to the slight dissociation properties of the acids and bases. For example, the dissociation of ammonium acetate should be:



But, due to the presence of free hydrogen ions and hydroxyl ions in water, these free NH_4^+ ions and $\text{C}_2\text{H}_3\text{O}_2^-$ combine to form the original acid (acetic), and base (ammonium hydroxide). The following equations will illustrate this fact:



The sum of these expresses the condition at equilibrium:



This property of weak electrolytes that suppresses the ionizations of strong acids and bases, with their slight dissociation, is responsible for the difference in the total acidity and the hydrogen ion concentration of solutions which contain them. This fact is distinctly shown in cane juices which contain many weak organic acids and their salts. A sample of a juice which contains malic, oxalic, acetic, citric, succinic acids has a definite hydrogen ion concentration at equilibrium. When a sample of it is titrated, these weak salts, etc., are neutralized and a value expressing the total potential acidity will be obtained which will be greater than the intensity figure.

In order to bring out more clearly this distinction of weak electrolytes, consider the titration of two acids, one strong, HCl, the other weak, acetic. If a .1 normal hydrochloric acid solution and a .1 normal acetic acid solution be separately titrated with .1 normal sodium hydroxide solution until they give a pink color with phenolphthalein, ten c.c. of each acid will require ten c.c. of the base and will therefore have the same acidity. Actually, however, hydrochloric acid is about sixty times as strong as acetic acid, for it is capable of ionizing to a degree sixty times that of acetic acid. During the titration of an acid, as soon as the ionized part of the acid has been removed by the base, a further amount of the previously undissociated acid dissociates. This process is repeated by further additions of base until the whole of the acid originally present has become dissociated, and the hydrogen ions have united with the hydroxyl ions of the base. The next trace of the base reacts with the indicator to produce the pink color.

That the dissociation of electrolytes is also a function of the dilution will be illustrated in the following table:

Dilution in C.C.	Acid % HCl	Acid % HF	Acid % H ₂ SO ₄	Acid % HC ₂ H ₃ O ₂	Base % NH ₄ OH
1	74.00	7.00	51.00	.40	0.40
10	95.00	10.00	57.00	.13	1.70
100	98.00	25.00	79.00	.50	4.40
1000	99.00	95.00	93.00	1.25	10.20

The figures expressing concentration in the equation:

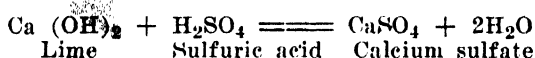
$$(\text{H}^+) \times (\text{OH}^-) = 1 \times 10^{-14}$$

must be expressed in gram molecules per 1,000 c.c. From this equation the value of one unknown can be calculated if the other is known. There are, in general, three methods of determining one of these values, they are:

1. Titration (Total acidity);
2. Indicators (Intensity);
3. Hydrogen Electrode (Intensity. Will not be discussed as plantations in the territory are not equipped with hydrogen electrode outfits.)

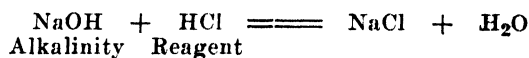
The titration method is based upon a chemical reaction.* For a complete understanding of this important method, the elementary principles of chemical reactions should be clearly understood.

Whenever chemical compounds, acids, bases, and salts react, they react in molecular quantities. A pound of lime cannot be mixed with a pound of sulfuric acid and two pounds of calcium sulfate be obtained. The following equation expresses this reaction:



This means that one molecule of sulfuric acid, molecular weight, $2\text{H} + \text{S} + 40 = 2 + 32 + 64 = 98$; and one molecule of calcium hydroxide. Molecule weight, $\text{Ca} + 2(\text{OH}) = 40 + 34 = 74$ have reacted, or are capable of reacting, and have produced one molecule of calcium sulfate, molecular weight 136, and two molecules of water. From this it is seen that chemical substances must be taken in proportion to their reacting masses.

The equation expressing the reaction used in the determination of alkalinity is:



This equation states that one gram molecule of HCl is capable of reacting with one gram molecule of an alkaline substance, OH, to produce a neutral solution. Whole gram molecules do not necessarily need to be taken; multiples or fractions of these quantities can be used. This is an important principle and is made use of in the use of small amounts of any standard reagent.

A titration is carried out by taking a definite amount of the solution of which the acidity is desired, adding a few drops of an indicator and the standard acid or base solution until a neutral point is reached. Suppose that fifty c.c. of a juice be taken and diluted to approximately one hundred c.c. A few drops of a litmus solution is added and the solution turns red. This indicates that the juice is acid. From a burette, a standard base solution is added until the color of the juice changes to that of pure water to which a like amount of litmus has been added. Suppose that twenty c.c. of a .1 normal NaOH solution was required to produce neutralization. What is the acidity of the juice? This is determined in the following manner: 1000 c.c. of the base solution contains .1 of the normal weight of NaOH, that is 1,000 c.c. is equivalent to .1 gram of hydrogen ion, then:

1 c.c. of base..... .001 grams hydrogen ion

20 cc. of base..... .02 grams hydrogen ion

therefore, since fifty c.c. of the juice is equivalent to .02 grams of hydrogen ion

1,000 c.c. must equal to $\frac{.02}{50} \times 1000 = .0004 \times 1000 = .04$ normal.

Titration gives, as indicated, the total amount present and gives no indication whatsoever of the intensity or the hydrogen ion concentration. This intensity of a solution is obtained by the use of organic dye substances, in solution, that have been standardized with solutions of known intensity.

Certain organic dye substances in solution form colored salts, acids, etc., or undergo intra-molecular arrangement or change in some manner when the hydrogen ion concentration of a solution has a certain value. Below is a list of such indicators; the hydrogen ion concentration range is expressed in grams per liter:

Range	PH	Color Change	Name
.7 to .000,6	.1— 3.2		Methyl Violet
.6 to .0015	.2— 2.8	Red to yellow	Thymol blue
.000,97 to .000,025	.3— 4.6	Yellow to blue	Brom-phenol-blue
.000,0402 to .000,000,996	4.4— 6.0	Red to yellow	Methyl red
.000,0062 to .000,000154	5.2— 6.8	Yellow to purple	Brom-cresol-purple
.000,000,996 to .000,000,02	6.0— 7.6	Yellow to blue	Brom-thymol-blue
.000,000,156, to .000,000,003,96	6.8— 8.4	Yellow to red	Phenol-red
.000,000,062,8 to .000,000,001,56	7.2— 8.8	Yellow to red	Cresol-red
.000,000,009,7 to .000,000,000,25	8.0— 9.6	Yellow to blue	Thymol-blue
.000,000,006,08 to .000,000,000,157	8.2— 9.8	Colorless to red	Cresol-phenolphthalien
.000,000,005 to .000,000,000,098	8.3—10.0	Colorless to pink	Phenolphthalien
.000,03 to .000,000,005	4.5— 8.3	Red to blue	Litmus (Asolitmun)

The last two indicators are not very sensitive, having a very great range of change.

From the equation developed from the dissociation of water:

$$(\text{H}^+) \times (\text{OH}^-) = 1 \times 10^{-14}$$

it was shown that a scale could be constructed in which the values would be expressed in terms of grams of hydrogen ions per liter, C_{H} and that even though the solution be distinctly alkaline this alkalinity could be so expressed. When an acid is added to pure water the hydrogen ions are increased. When a base is added to water the base dissociates, i. e., furnishes OH^- and by this simple process a lowering or shifting of the C_{H} can be brought about.

Since it is often necessary to tabulate and graph values of hydrogen ion concentrations it is very convenient to have them in the most simple form possible. Values expressed with negative exponents, or decimal fractions exceedingly small, are far from simple. In order to overcome this unwieldiness a manner of simplifying was evolved. To this simplified unit the term P_{H} was given; its relation to hydrogen ion concentrations is expressed in the following manner:

$$P_{\text{H}} = \text{Log } \frac{1}{C_{\text{H}}}$$

In words, this expression means that the P_{H} is equal to the logarithm to the base ten of the reciprocal of the hydrogen ion concentration expressed in

grams per liter. In order to illustrate the use of this expression an example will be given.

The strength of a .01 normal hydrochloric acid solution, that is a solution of hydrogen-chloride containing .365 grams of the compound per liter, expressed in terms of hydrogen ion concentration is approximately .0096 gram of hydrogen ion per liter, or 9.16×10^{-3}

$$P_H = \text{Log} \frac{1}{9.16 \times 10^{-3}}$$

$$\text{Log} \frac{1}{9.16 \times 10^{-3}} = \text{Log} \frac{10^3}{9.16}$$

$$= \text{Log} 10^3 - \text{Log} 9.16$$

$$3 - .96 = 2.04$$

$$P_H = 2.04$$

In order to show the relation between P_H , C_H , and C_{OH} -the following table has been prepared. This table very clearly shows the balancing of the H^+ and OH^- , as one increases the other decreases:

TABLE INDICATING RELATIONSHIP BETWEEN P_H , HYDROGEN AND HYDROXYL ION CONCENTRATIONS IN TERMS OF NORMALITY

$$P_H = \text{Log}_{10} \frac{1}{C_H^+}$$

	P_H	C_H^+	C_{OH}^-
ACID	....	1	.000000000000010
	.98	.105	.000000000000096
	1.285	.0519	.000000000000195
	1.995	.0101	.000000000000101
	2.295	.00502	.000000000000200
	2.975	.00106	.00000000000090
	3.280	.000525	.0000000000019
	4.023	.0000947	.000000000010
	5.004	.00000991	.00000000010
	6.002	.000000996	.000000010
	6.999	.000000100	.00000010
		NEUTRAL	
ALKALINE	7.506	.0000000312	.000000324
	8.030	.00000000933	.00000108
	9.011	.000000000975	.0000104
	10.008	.0000000000981	.000103
	11.022	.00000000000950	.00107
	12.003	.000000000000993	.0102
	13.107	.0000000000000961	.105
	14.032	.0000000000000930	1.09

Report on the Effect of the Petree Process at the Mills and Furnaces as Experienced at Puunene Mill This Past Season*

BY ROBERT E. HUGHES

At our last convention, we had with us, Mr. Petree of the Petree & Dorr Company, who explained in detail the working of the Petree Process in connection with, the Dorr Clarifiers, therefore, it will not be necessary to enter into any explanation of the Process in this report.

No doubt, you have all studied, more or less, the Process since then, and followed very closely the working of it at both the Hawaiian Commercial & Sugar Company's factory at Puunene, and the Maui Agricultural Company at Paia.

The Process and apparatus was something entirely new in the Islands, and there was considerable to learn about the working of it. This especially concerned the unskilled labor, who were in the habit of doing their work a certain way, and consequently it took time to train them so that they would fit into the new way.

To us all it was a new experiment, both in the factory and at the mills. In fact, the Process had never been tried anywhere in connection with a shredder, so it must be realized that a perfect run at first was not to be expected with this, any more than was experienced with many other extensive changes made in other years.

The Dorr Clarifiers as installed, consist of one five-compartment and one four-compartment primary tanks, and two four-compartment secondary tanks, with their regular equipment of Dorr Company pumps, overflow tanks, etc.

A one-thousand-gallon cone bottom tank was placed near the clarifiers and on the same floor to receive the mud, thereby providing for some differential between the clarifier discharge of settlings and their application to the blanket of cane at the mills. This was made necessary, owing to the fact that with different varieties of cane the amount of settlings would be greater or less, or they would vary in density to some extent, due to the quality of the juice in process. A poor settling juice requiring faster pumping to maintain the proper mud level in the clarifiers.

The draw-off valve controlling the outlet of this mud tank is located in a convenient position at the mill, it being set to allow an even flow of mud to the cane.

An electric signal consisting of four lights placed in a prominent location at the mills, with corresponding switches in the mud tank, automatically indicates the number of feet of mud contained therein.

* Presented at the Second Annual Meeting of the Association of Hawaiian Sugar Technologists, Honolulu, October 22, 1923.

Though endeavoring to maintain an even flow of mud on the cane in quantities equal to the discharge from the clarifiers, it was found at times quite impossible to do so without large quantities of the mud draining away with the juice, thereby being returned in process again through the secondary Dorr supply tank. At this time there appeared to be a great deal of mud returned into process and circulating within the secondary trap. This was thought to be due to the enormous quantity of cush-cush in the mud.

A Peck revolving juice strainer was then installed. This strainer is three feet in diameter by six feet long, and was installed to restrain all the primary juice from the "B" Mill. An improvement in the grinding rate, due to less mud, was noted after this installation, so another strainer was installed to restrain the Mill "A" primary juice before pumping it into the boiling house.

These strainers did wonderful work, removing great quantities of cush-cush, a large percentage of which when washed, would pass through a one hundred-mesh screen, indicating that the cush-cush itself was acting as a filtering medium. In this manner considerable grit and mud were removed as well.

Some mechanical trouble was experienced with the strainers as first installed, but this was soon corrected, so the straining of two-thirds of all the juice from two twelve-roller mills, grinding at 90 to 115 tons of cane an hour, proceeded without any delay caused by these strainers.

Less mud being returned from the clarifiers, owing to the previous removal of cush-cush, allowed our speeding up the mills to take care of the almost daily increasing quantity of cane supplied.

It will be interesting to note here an experiment carried on with this strainer during the last few weeks of the season.

As we desired to know the maximum capacity of the strainer, and to experiment further with the straining of both the primary and secondary juices, two additional paddles were attached to the "B" strainer, and suitable piping installed to carry all the Mill "A" primary juice over to join Mill "B" primary, the combined juices to pass through the "B" strainer. Though the strainer was crowded, it took care of the combined primary juices, amounting to two-thirds of the total juice from both mills while grinding at the rate of 115 tons of cane an hour with dilution of 46.63 per cent. Mill "A" strainer was used to strain all the secondary juice from both mills.

The juice was limed after straining, so that all screenings were returned to the mills minus the lime. This had a somewhat noticeable improved effect on the rollers, especially on the second mill where the mud was applied.

All the juice now being re-strained, which practically removed all the cush-cush, nothing but the mud and settlings were left to be removed with the lime.

Though greatly improved conditions were obtained by the installation of these strainers, there was still a great deal of trouble experienced with the mud on the mills.

Mill settings were the same as those used in previous years, and with which we have obtained some high extractions. Some dry crushing tests to show what has been done in previous years with these same settings will be of interest here:

Mill			
Cr.	61.7	} 81.8	55.3
1	20.1		27.1
2	6.9		6.5
3	0.8		1.0
4	2.5		1.0
Total	92.0		90.9

These figures are presented to show the extraction obtained by the crushers and first mills before processing, so it is not unreasonable to say that with mill settings and weights practically the same this past season, one would expect the quality of work in the mill to be about the same up to this point.

However, our failure to obtain an average extraction of 98 per cent was due to the excessive amount of rich juice returned to the mills with the mud.

This juice and mud contained a higher percentage of sugar than was contained in the cane entering the second mill, and as there was such a large quantity of juice returned, at times as much as thirty per cent of the cane, it was impossible to effectively apply the proper amount or quality of return maceration that would be required to obtain an extraction of 98 per cent.

When by-passing the third mill juice which normally is used for dilution, we found there would be much less choking, less mechanical conveying and draining away of muddy juice.

This by-passing was not according to process or good milling practice. However, it was only to show the effect that less juice had on the washing out of the mud and choking of the mills.

When operating as a twelve-roller mill, all low density juice must be returned to obtain a fair extraction.

A very noticeable change in the density of the mud took place after a shut-down of say an hour or so, particularly when starting up after the week-end shut-down; the first mud to the mill was always very heavy and more compressed, but it did not remain so.

While operating with this heavy mud, it was plainly indicated, by the darker color of the blanket, that the mud remained mixed with the cane until it reached the furnaces.

The temperature of the mud ranged from 200 to 210 degrees F., this, and the fact that it contained so much juice, caused this choking effect. Forty-seven per cent of the mill breakdown time was due to mill chokes, this in turn caused a slowing down of the grinding rate, for the mill feeder was compelled to feed the mill at a rate which would enable our taking care of the mud.

This choking effect was aggravated by the smoothing of the rollers, the lime counteracting the etching of the rollers by the natural acid contained in the raw juice.

The surface wear of the rollers was practically eliminated, though the very necessary regrooving or sharpening of the grooves at short intervals made up for the reduced wear.

Having established a standard grooving of our own that has taken some years and expense to install, as well as having had excellent results with the

grooves as arranged, we naturally look upon any changing of grooves with caution.

The feed rollers are grooved $\frac{3}{4}$ " pitch, and it became necessary to nick up the surface of these rollers a number of times during the crop.

The liming machines worked well throughout the season. However, when re-straining of juice is practiced, a liming machine equipped with a motor drive will be found to have many advantages over the mill drive.

The Petree Process has, no doubt, contributed to a considerable extent to our great saving of fuel over previous years, by eliminating the mud press and filtration stations, also by the settlings returned to the mill. However, the settlings were greatly reduced by the Peck strainers, removing practically all the mush before clarification, and they should be credited with this saving.

It so happens that other charges made during this same season, caused a saving of much fuel.

Two 300 H. P. boilers formerly equipped with oil burning furnaces and used as boosters, were added to the high pressure steam line as continuous generators, by changing the furnaces to the bagasse burning type.

Another change was that made to the bagasse-burning furnace grates, which permitted the bagasse to burn freely and evenly by preventing the short circuiting of air required for combustion. By this change a higher and more uniform furnace temperature was maintained.

Molasses was burned when the mill operating at a low tonnage supplied an insufficient quantity of bagasse to the furnaces.

An outside load as high as 600 K. W. was carried by the mill electric plant for some months, enough power being sold in this way to give the mill a credit balance.

It is interesting to note that for about twelve days (from December 21st to January 3rd), for a special reason, operations were carried on without Petree Processing. During this interval the mud presses were used and no very noticeable change took place at the boilers; the surplus bagasse pile continued to grow despite the fact that we were grinding at a low tonnage rate, no outside load being carried at the time.

However, there are many other stations throughout the factory where a saving of steam can be accounted for, owing to the perfect clarification by the Dorr Clarifiers, and the removal of mush-mush by the Peck strainers before liming and heating take place. At the heaters, less steam was required owing to the absence of mush-mush in the juice passing through; at the evaporators, less steam was used, due to higher temperature of the clarified juice entering the first cell, and the absence of wash water from the presses. At the vacuum pans less steam, due to better syrup, remelt and molasses. At the centrifugals, power was saved owing to the fact that the much freer drying of both the commercial and low grade sugars permitted our operating this station with only sixty per cent of the centrifugals used in previous years.

The mud had a beneficial effect if any, at the furnaces, and though there was a slight increase in the amount of clinker and ash, it was of a softer composition and easily removed.

A number of improvements in connection with the Process are being looked forward to this season, all of which we expect will help to correct the objectionable features experienced during the past year.

Three Peck strainers will be in use, one to re-strain Mill "A" primary, another Mill "B" primary, the third to re-strain the secondary juices from both mills.

Experiments with a finer screen will be made, commencing with 120 mesh on the primaries and 150 mesh on the secondary strainer.

Below the strainer will be located the primary and secondary juice tanks with their respective pumps. On the top of the primary juice tank is placed the liming machine, which has been converted into a double limer and equipped with motor drive.

The liming of juice from both mills will be done here with one machine.

All the clarifiers are to be fitted with two Dorr Company mud pumps; they can then be operated slowly, and pump without the application of water to the suction side of the pump, which practice had to be resorted to, for the vapors released from the hot mud interfered with the suction. This additional water intensified our troubles at the mills.

The Dorr Company now recommends the lowering of the mud pump to the side of the clarifiers, in place of mounting on the top as at present.

This reduction of suction lift should be a decided improvement, and one which should enable us to obtain a heavier mud.

A Report on Tasseling*

BY W. P. ALEXANDER

The subject of the tasseling of sugar cane in its commercial aspect must be divided into two groups, namely:

1. The natural inflorescence of the cane stalk, which has passed through one winter season and which is about to approach the harvesting period.
2. The tasseling of the cane stalk after its first growing season, which is premature.

In the first case the cane is from 16 to 20 months old, and in the second case from 6 to 11 months old.

The phenomena of tasseling of nearly ripe cane has not caused any special cultural operations. On the other hand, the prevention of the tasseling of the "small cane" (mentioned in Group 2) has given much concern on practically all irrigated plantations. On unirrigated plantations also, where Yellow Caledonia is not grown on the lower fields, they have the "tassel problem." The drastic practice of "cutting back" ratoons in July, and also later planting have been a logical means of combating this "evil" of early tasseling.

* Presented at the Second Annual Meeting of the Association of Hawaiian Sugar Technologists, Honolulu, October 22, 1923.

In the hope of bringing together data which would review our present knowledge of the flowering of sugar cane, the writer prepared and sent out a questionnaire to members of the Association. While the replies received were few in number, those who did send in complete answers, show that this topic is receiving more attention than it ever has from plantation men.

The writer is indebted to the following for their contributions and interviews in making this report possible: Messrs. H. P. Agee, W. W. Goodale, L. A. Henke, W. P. Naquin, F. A. Paris, J. S. B. Pratt, Jr., Geo. F. Renton, H. D. Sloggett, H. E. Starratt.

All agree that our *exact* sum of information on this annual event in our cane fields is small. We notice that in some seasons tasseling is heavier all over the plantation than in other years; we observe that some fields bloom more thickly, while adjacent fields have but a small number of flowers; we discover that within an individual field some areas are "solid" with arrows, and not over one hundred feet away the cane may be barely sprinkled with tassels.

From our experience and observations we may formulate certain theories and ideas on what we see, only to have them contradicted from year to year. So it sometimes seems that our explanation of nature's workings in regard to tassels becomes mere guess work.

This report, therefore, hopes merely to record the observations and experiences of field men. It should start discussion and open up investigation along this line of research.

Both the normal flowering and premature flowering of the cane warrants study. It is interesting to note that not since 1908, when the late H. P. Baldwin advanced his theories on tasseling and urged more attention to the question, has the subject been under discussion with any concrete data on the *whole* subject. The effect, not only on cane yields but also on sugar content, is so great that a better understanding of this annual function of sugar cannot but be rewarded. If the cane agriculturist can have a directing influence over the tasseling of cane, so that his aims will be accomplished, we have advanced one more step in our cultural methods.

Like everything else connected with the growing of cane in the Islands, conditions vary so greatly, that each district and often individual plantations must determine for themselves the specific factors that enter into their own problem. Generalities cannot be made covering all situations.

TASSELING OF MATURE CANE

Variety Influence on Tasseling:

Perhaps the most consistent observation every one makes, is that the desire of the cane to tassel is not the same for all varieties. They differ as regards the time of tasseling, quantity of arrows, and ability to keep growing after flowering, by means of lalas. This is a most important and practical point. It means that it is possible to obtain the degree and amount of tasseling which is wanted, by the proper selection of our new seedling canes.

The fact that Yellow Caledonia does not tassel freely, will lala, and not die back if tasseling does occur, has added to its attractiveness under unirrigated con-

ditions. It was abandoned on many irrigated plantations for this same ability to keep growing, because this factor prevented securing high sucrose content.

Professor Henke, of the University of Hawaii, has contributed an interesting table (see Exhibit A) showing the time and quantity of tassels for different varieties.

Yellow Caledonia and Big Ribbon show the least, while Striped Mexican, White and Rose Bamboo, and H 146 head the list. Then comes D 1135 and H 109 and Lahaina in between these extremes.

Badila and Uba are very late tasseling canes. Yellow Caledonia and Tip canes appear in December just after D 1135. H 109 arrows are usually the first ones seen.

Elevation Influence on Tasseling:

There appears to be a direct correlation between elevation and tasseling of the cane. All report practically no tasseling at sea level to a 25-foot elevation. This is particularly true at Ewa, Pioneer and Waialua. There are varying amounts from 25 to 50 feet, but still *relatively* small. Beginning at an elevation of 50 feet, the quantity of cane stalks which tassel increases in direct ratio with the elevation, up to 500 feet elevation. Then there is a falling off until the elevations above 1,000 feet are almost free of tassels. A conspicuous example of this is Hawaiian Agricultural Company at Pahala, Kau, where tassels are known only on a few lower fields.

Figures submitted by Mr. Naquin give 300 to 450 feet as the elevations at which maximum tassels may be secured. From personal observation on Oahu and Maui, the writer believes this to be true also for other conditions beside those at Honokaa.

It then seems established that the kind of cane and the elevation at which it is planted will be two factors in determining how many tassels will be produced. Knowing these facts we are in a position to plant our new and old varieties accordingly.

Mr. Agee doubts if elevation *per se* has an influence on tasseling of cane, but believes that climatic conditions resulting from different elevations do.

Influence of Local Environment:

We would expect local environment of the cane to influence the forces of reproduction of the plant, which is the motive of tasseling.

Length of Day:

Investigations under way by the U. S. Department of Agriculture at Washington, D. C., are proving that it is the amount of sunlight a plant receives that determines the flowering period. In other words, the shortening of the daylight is the chief element in causing many plants to change their directive force from growth to reproduction. There is every reason to believe that this cause applies to sugar cane. The writer has found that the first tassels on Oahu appear at Kahuku, in the fields which after September are in the shadow of the western cliffs late in the afternoon. Mr. Agee points out that cane at the Manoa substation shows a tendency to tassel earlier than at Makiki. The field is located at the foot of a 1,000-foot cliff which is on the western side.

It may be that we can account for the different times at which cane first tassels from year to year, by the varying amount of cloudy Kona weather so common in September and October.

The first flags are sent out in the last week in October or the first week in November according to most reports. The maximum amounts appear just about December 1. Tassels are seldom seen appearing after February 1. A few of the "late varieties" bloom in January.

The lowest elevations have the first arrows, but as Mr. Naquin explains: "While tassels appear at higher elevations later than elsewhere, this is probably due to the fact that the growth up mauka is less than at lower elevations for the same length of time, and even though the tassel is formed in the leaf sheath at the same time, it does not appear, owing to the greater lapse of time which is necessary for a given unit of growth."

Temperature:

Shortening of sunlight is probably assisted by the growth check due to a reduced temperature after August 15, in promoting the tasseling of cane. It has been thought that a sudden drop in the *average* daily temperature, such as a series of cold nights, would result in more and earlier tasseling; and yet others hold that when there is the least daily range in temperature cane tassels most profusely. In 1920, at the Annual Meeting of the H. S. P. A.,* this was discussed pro and con. The late Mr. Baldwin† also advanced his theories in 1908, which held that a high uniform temperature favored tasseling.

Moisture and Plant Food:

While man cannot control the above factors of temperature and sunlight, on irrigated plantations moisture can be regulated, and on all fields artificial plant food can be administered. Later on, it will be shown how the maintaining of the growth desire of the *young cane* plant can be largely influenced by the right application of irrigation water and nitrogen. We are now dealing with the mature cane.

The question of the effect of fertility and moisture on the tasseling of *big cane* appears to be a baffling one to all. Are we right in saying: Give a mature cane perfect growing conditions and you lessen tasseling? As Mr. Naquin says, it is almost impossible to put one's finger on the exact influence that variation of the soil and moisture content has. In 1922, several fields (19-B and 1-A) at Ewa, that were being ripened, had irrigation suspended, two months previous to November 1st. They produced less than 2 per cent of tassels, while adjacent fields (17-E and 1-F) that had been irrigated steadily, tasseled as heavily as 15 per cent in places. Mr. Naquin states, "In 1917, after a dry spell of ten months, practically no tassels appeared, while in 1918 which was a wet year, the cane tasseled profusely up to 800 feet elevation." To quote Mr. Brecht: "Where there is more water the cane tassels freely."* Mr. Paris observed, "We noticed that cane growing in wet spots was tasseling heavily, where surrounding cane situated on higher land was not tasseling at all. Perhaps Mr. Naquin is

* Proceedings H. S. P. A., 1920, pp. 244-5.

† Proceedings H. S. P. A., 1908, p. 17.

right when he says: "It is an abnormal or a subnormal condition which has a check on tasseling," and Mr. Paris has the same idea: "We may also have a high proportion of tassels in the autumn as a normal end of an exuberant existence."

More experimental evidence is needed, however, to definitely show why, sometimes under very favorable moisture and plant food conditions, cane will tassel, and then again given adverse conditions cane will *not* tassel or vice versa.

Fertilizer does not *always* work on *big cane* to hinder tassels. As the late Mr. Baldwin expressed it years ago, "I have always found that the main factors that affect the tasseling of cane are water, temperature and air." He laid stress on the prevention of the circulation of air in heavily fertilized cane as a cause for small number of tassels.

The general observation is that all fields tassel heavily on the outside. Mr. Paris expresses his theory of this as due to the wind, giving two reasons: "The quick evaporation of the moisture in the soil causing irregular growth of the plant, and the disturbing effect of the wind on the root system. The stalks are pushed over by the wind, the roots broken or the contact between them and the soil, becomes imperfect, thus preventing a good circulation from the roots to the upper part of the plant, causing insufficient nourishment."

The writer is inclined to guess that the tassels along the edge are caused by a *slight* checking of growth following a quicker drying out of the soil in this portion of the field. Also the changes in temperature are greater on the exposed side of the field.

Such tasseling along the edge of the field and ditches is deceiving as to the true proportions of stalks within the field which are actually flowering.

The writer had noticed that tassels were thicker along the watercourses, but was surprised to find that counts in 1923 showed that the ten feet of cane on each side produced over half (51.09 per cent) of the total flowers in the field. These counts represented 62 lines taken from *all* the fields.

The "Baldwin Theory" of the circulation of air may account for the amount of tassels on the edge of the field and near the watercourses. The writer also believes that the large amount of water, with the successive abnormal wetting and drying out which this cane is subject to, may have some effect on this cane adjacent to watercourses.

Influence of Plant and Ratoon Cane:

At Ewa, mature plant cane does not tassel as heavily as ratoons. The following average figures based upon counts verify observations:

	1922	1923
Plant Cane (5 fields).....	4.06%	5.22%
Ratoon Cane (5 fields).....	9.27%	9.13%

Mr. Paris believes that on Oahu, plant and ratoon cane tassel in about the same proportion when conditions are favorable for it. Mr. Naquin has made counts of tassels in 30 fields of plant, first, second and third ratoons and concludes, "There is but a slight difference in the amount of tassels sent out by the

plant and ratoon cane, and on account of the wide variation in soil conditions, it is almost impossible to arrive at accurate figures."

Age of Cane:

The age of mature cane influences the percentages of tassels to some extent, but may be outweighed by other factors, such as elevation. At Honokaa, 15 months cane in 8 fields at different elevations averaged 15.25 per cent, while 10 months old cane 12.25 per cent, and 5 months old cane gave no tassels.

Effect of Tasseling on Mature Cane:

Before one can determine the effect that tassels have on mature cane, one must know how many stalks have arrowed.

Anyone making counts will be surprised to find how misleading observations are. A field which presents a solid purple hue and in which it appears that every stalk must have tasseled, will be found to have but 50 to 60 out of every 100 with a flower, more often the percentage will be less. Counts have been made at Ewa for three years, of the percentage of tassels in each field, and the results below give summarized figures of that portion of the plantation having specific amounts of tassels:

Fields With	Per Cent of Total Area	
	1922	1923
No tassels.....	12.60%	4.13%
Trace	18.66%	26.89%
Only tassels along edge.....	22.17%	2.82%
Under 5%	12.52%	30.69%
5 to 10%.....	7.45%	15.74%
10 to 15%.....	5.67%	16.16%
15 to 20%.....	2.95%	0.00
20 to 30%.....	8.19%	2.28%
30 to 50%.....	4.65%	1.29%
Over 50%	5.14%	0.00

Averaging figures from all fields where counts were made at Ewa we secure:

1922 crop.....	8.06 per cent tassels
1923 crop.....	8.30 per cent tassels

The highest percentage reported by Mr. Naquin is 44 per cent. His average figure would be 19.21 per cent.

Cane stalks which have *recently* tasseled have a higher sugar content than those that are continuing to grow. These tests are average figures of a good number of samples from H 109 at Ewa Plantation:

	Brix	Pol.	Purity	Q.R.
Tasseled Stalks (no lalas yet).....	18.24	16.61	91.06	7.88
No tassels (no lalas yet).....	17.72	15.58	87.92	8.60

However, after several months have elapsed the reverse seems to be true for unirrigated conditions. The difference in tests at Honokaa were small but in favor of non-tasseled D 1135 cane.

	Brix	Pol.	Purity	Q.R.
No tasseling (3 months after).....	18.43	16.92	91.81	7.69
Tasseled Stalks	18.26	16.62	91.02	7.87
No tasseling (6 months after).....	17.56	15.96	90.89	8.21
Tasseled Stalks	17.44	15.61	89.51	8.48

When the cane tassels three things may happen: (1) the stalk will send out lalas or side shoots from the topmost eyes; (2) all growth of the stalk will cease and the cane will eventually die back; (3) new growth will be concentrated in sending out suckers from the original stool. So it would seem while there is a storage of sugar in the tasseled stalk to begin with, this condition is temporary. The juice of the lalas and suckers are poorer, and any such growth draws upon the accumulated sugar in the main stalk. When the cane dies back without lalas, deterioration of the sucrose sets in.

Granted that there may be a slight increase in sugar content when development of the cane is arrested by tasseling, indications are that this gain is not permanent and may be more than offset by the tonnage of cane lost in the interrupted growth.

Therefore, unless the cane is to be harvested within several months after tasseling, the flowering of the stalks is not beneficial. This is especially true in dry regions. Mr. Naquin explains the reason: "As a great deal of growth in this district is made in the winter months, when water is not a limiting factor, we feel tasseling is not desirable. We have found that under certain conditions cane does not lala, consequently it dies out and there is a double loss. Mr. Paris adds this idea: "After heavy tasseling, the suckers are likely to be numerous, especially on good soil. They spoil the juice."

TASSELING OF IMMATURE CANE

As has been stated before, it is the tasseling of half-grown cane following the first season, which is the "bugbear" of many plantation men. To prevent this, the practice of "cutting back" in July has been in vogue.

Under what conditions does cane (plant or ratoon) tassel after the first season? What proportion of the stalks tassel? Do the canes that tassel produce new side stalks or lalas? How does irrigation affect the tasseling of this cane? Will nitrogen fertilizer influence the tasseling of the cane? Is cutting back necessary? Is late planting necessary?

The above questions are involved one with another and cannot be answered definitely for all conditions.

What has been stated in regard to the influence of varieties, elevation and local environment, etc., on mature cane applies in a general way to young cane. The age of the crop, however, plays a more important role in this immature cane.

Ratoons: Cane harvested in January will arrow the following November, unless grown on the very lowest or highest elevations and from the lesser tasseling varieties such as Yellow Caledonia or Badila. This applies in a lesser extent to February and March harvest. April cut cane will or will not tassel, depending on conditions. Cane cut in May probably will not arrow. June cane is almost safe, though there are exceptions.

Plant: Cane ordinarily can be planted after May 1 without fear of much tasseling. Opinion and experience from fields planted earlier differ greatly. At Ewa, plant cane of H 109 will not produce many tassels, although started in February.

The above summarizes what many cannot agree upon, because the tasseling will vary so much with seasons and local conditions.

The proportion of stalks tasseling in cane, harvested or planted in different months, has not been worked out experimentally for all conditions. Actual counts will show that except for exposed fields and those on higher elevations (above 150 feet) the numbers will be negligible, i. e., less than 8 per cent. For those fields cut during and before March, the amount will depend largely upon treatment, but should not be over 20 per cent.

Most varieties that are planted below 1,000 feet elevation will bring forth *lalas*, if there is not extreme cold and dampness.

Fertilizer, in quick acting nitrogeous form, has a decided effect on reducing and often preventing tasseling of immature cane, provided it is applied at the right time, and followed with *sufficient* irrigation. We have seen this demonstrated at Ewa, not only in experiments but also in field practice.

Cane irrigated *regularly* (not over 20-day intervals) from August through November stands a much better chance of not tasseling. Any check to the growth of cane during this period, either due to a lack of plant food or not enough soil moisture, will be liable to change the "growing desire" of the plant to one of reproduction, i. e., tasseling. The shorter days and colder weather are pulling one way, and to counteract their influence the growing environment must be made as favorable as possible.

Whether it is necessary to "cut back" all cane started before June 15, either in plant or ratoon, is a question to be decided by each plantation, irrespective of what others are doing. It was hoped to present the views in detail of those who favor cutting back and practice same. The answer to the writer's question, "Does cutting back pay?", was merely answered in the affirmative.

The wish of all field men who are responsible for maximum yields, to play safe, is justified, provided the practice of cutting back is not merely one of rule of thumb, but is backed with experimental evidence.

The matter has been decided for the Ewa Plantation Company by Manager George F. Renton, Jr., as follows:

All cane to be ratooned, cut previous to March 31, will be a short ratoon, so while tassels are not wanted, their influence if they do appear, will not be injurious. There is no cutting back of any field. Fields at the higher elevation are taken off later. Fields harvested in April and May will be given special treatment to minimize the opportunity for tassels to appear in November. The above policy is based upon experience with H 109 in field practice plus the results from five experiments conducted under different conditions on the plantation. These tests showed that "cutting back" brings no benefit to the growing crop. In fact, four out of the five experiments registered a distinct gain for non-cut-back plots, viz:

Field A. S. Co. No. 2.....	1.99	tons	sugar	per	acre
10-A.....	1.83	"	"	"	"
19-B.....	1.12	"	"	"	"
1-C.....	.77	"	"	"	"
<hr/>					
Average	1.43				

The fifth experiment in Field 1-A gave neither a loss nor a gain for not cutting back.

By not cutting back, the labor was saved in two ways: The men used in performing this operation were eliminated; fewer men were required in hoeing, as the cane closed in quickly and shaded out the weeds.

In 1920, Mr. Allen, then at Kilauea, found that a field in which there were 48 per cent of tassels after the first season continued to grow so that the stalks with lalas weighed more than those canes which had not arrowed.* Calculation showed that the tasseled stalks would produce 4.0 tons of cane per acre or .35 tons of sugar per acre more than the untasseled canes.

Here, then, is some proof of the contention held by many, including the writer, that where a variety will lala, a small percentage of tassel will not damage the ultimate yield. The growth of lalas, while probably poorer under most conditions than continuous growth, will, nevertheless, offset the great loss in growing time which cutting back causes.

Mr. Naquin, of Honokaa, states that: "We do not feel that under any conditions cutting back of young cane is justifiable." Mr. Agee tells how at Oahu Sugar Company a field of Lahaina cane with 16 per cent tassels when small showed a gain for no cutting back. Mr. Hind,† of Hawi, has called attention to the fact that cutting back with some varieties and under certain conditions brings about too rank a growth and consequently smaller sticks, and in many instances it is more advisable to risk a small per cent of tasseling rather than resort to cutting back. Mr. Paris goes into great detail and is very emphatic about losses due to cutting-back. His remarks proving his contentions with hypothetical figures are found in his report in its appendix.

Referring to the Annual Proceedings of 1920, H. S. P. A., it is evident that cutting back is on the decline; for example, in 1916 the Hawaiian Commercial and Sugar Company cut back 4,600 acres, while in 1920 only 600 acres were cut.

The tasseling season is at hand again, and when the members of the Association return to their respective plantations it will pay them to observe for themselves, the causes and effects of the tasseling. Then, perhaps, at our next annual meeting new data may be placed before the Association.

SUMMARY

1. Tasseling of cane is not the same for all varieties. Cane breeders need to watch tasseling.

* Hawaiian Planters' Record, Vol. XXVI, p. 90.

† Report of Committee on Cultivation, Fertilization and Irrigation of Irrigated Plantation, 1920, p. 18.

2. The shortening of the amount of sunlight which cane receives upsets the equilibrium of a plant so that it wishes to reproduce. Tassels are the result in cane.

3. Tasseling of cane differs for different elevations.

4. There are differences of opinion as to just what effect climate, as reflected in temperature, has on tasseling.

5. Moisture and soil variations influence the amount of tassels. Normal growth conditions favor tasseling.

6. There is evidence that mild air currents or more violent winds affect cane so that it produces tassels.

7. A greater yield of cane can be secured if mature cane does not tassel. The winter growth is desirable under most conditions.

8. What little data has been secured indicate that if, at least under unirrigated conditions, tasseled cane is not harvested fairly soon after flowering, poorer juices will result than if the cane had not tasseled.

9. A certain amount of immature ratoon cane will tassel if harvested previous to May 1. Cane planted in January to May may also tassel during the first season. Under some conditions this can be minimized or prevented entirely by specific treatment.

10. Cutting back in July to eliminate tasseling is too drastic treatment. Experimental data is necessary to determine if this practice can be avoided.

11. Proper application of fertilizer and irrigation is the remedy offered to reduce the percentage of tasseling in immature cane.

12. More experimental data is needed to show what percentages of immature cane can tassel without a harmful effect. Indications are that, provided a cane will lala, damage is overestimated.

13. Cutting-back is not being practiced on such a large scale as formerly.

APPENDIX

QUESTIONNAIRE ON TASSELING

I. Questions regarding the tasseling of cane that is almost mature.

(a) **Time of Tasseling.**

1. When do tassels first appear?
2. When may tassels last appear?
3. During this period, when do the majority of tassels appear?
4. What effect has climatic conditions on time of tasseling?
5. What effect has elevation on time of tasseling?
6. Do different varieties tassel at different times?

(b) **Quantity of Tassels.**

7. What proportion of cane stalks send out tassels under the following varying conditions? (Give actual counts if you have made them.) Variety; Plant cane; Ratoon cane; Types of soil; Elevation; Poor and good drainage; Protection from wind; Exposure to wind.
8. Are varying climatic conditions from year to year responsible for different amounts of tassels?

(c) **Effect of Tasseling.**

9. In your opinion, how is (1) the cane yield and (2) the sucrose content influenced when:
 - a. Tasseling is less than 10 per cent;
 - b. Tasseling is from 10 to 25 per cent;
 - c. Tasseling is from 25 to 50 per cent;
 - d. Tasseling is over 50 per cent.
10. Do you favor tasseling of cane that is to be harvested within six months from the time of tasseling?

(d) **Cause of Tasseling.**

11. What do you consider the cause of tasseling?
12. Can tasseling be controlled by:
 - a. Fertilization?
 - b. Irrigation?

II. Questions regarding the tasseling of cane less than one year old.

13. Under what conditions will cane cut in the following months tassel during the next winter: January? February? March? April? May? June?
14. Do you consider it necessary to cut back cane started in the above months? If so, when would you cut back?
15. Will the cane require special treatment if no cutting back is practiced?
16. Assuming that this immature cane does tassel (a) less than 10 per cent; (b) 10 to 25 per cent; (c) 25 to 50 per cent; (d) over 50 per cent; what effect will this have on the ultimate yield?

(CONTRIBUTION FROM W. P. NAQUIN, OF HONOKAA.)

The natural function of any plant is to flower and reproduce itself by seed, and accordingly the tasseling of sugar cane is a natural phenomenon. Sugar cane belongs to that class of plants which produces flowers in the winter months, the flowers being induced by the shortening of daylight hours. Since cane at higher elevations tassels less frequently than that at lower elevations we believe that low temperature will check the tasseling of cane.

The age of the cane is also a factor in the number of tassels which will be produced, as is clearly shown in the following table:

EFFECT OF AGE AND ELEVATION ON THE TASSELING OF SUGAR CANE

Variety D 1135

Elevation Feet	Per cent Tassels		
	15 Months	10 Months	5 Months
300	20	22	0
350	24	13	0
400	26	10	0
450	25	21	0
500	10	11	0
550	4	15	0
600	10	4	0
650	3	2	0
Average	15.25	12.25	—

In the Hamakua District tassels generally appear from the 10th of October to the 1st of February. The majority appear from November 1st to 30th—the prevailing weather having quite an affect in determining the amount of tassels which occur from year to year. In 1917, after a dry spell of ten months, practically no tassels appeared, while in 1918, which was a wet year, the cane tasseled profusely up to the 800 feet elevation. A greater

number of tassels appeared at the lower elevation, in fact at the 1,800 feet level there were no tassels. When they do appear at the higher elevations they appear relatively later than elsewhere. This, however, is probably due to the fact that the cane growth up mauka is less than at lower elevations for the same length of time, and even though the tassel is formed in the leaf sheath at the same time it does not appear, owing to the greater lapse of time which is necessary for a given unit of growth.

There is also a difference in time of tasseling in the different varieties. In certain years in this district Uba and Badila tassel late, from the 1st of January through to February, while H 109 and D 1135 tassel before the end of the year.

As far as we can learn there is but slight difference in the amount of tassels sent out by plant and ratoon cane, and on account of the wide variation in soil conditions it is almost impossible to arrive at an accurate figure on this. We have, however, prepared a table showing such variations, which is given herewith:

EFFECT OF RATOONING ON TASSELING OF CANE.

Variety D 1135.

Elevation Feet	Plant	Per cent Tassels		
		1st Ratoon	2nd Ratoon	3rd Ratoon
300	25%	14%	53%	0%
450	11	23	5	44
450	26	20	0	24
450	44	27	28	32
450	0	21	0	24
500	15	23	13	16
550	34	34	8	19
550	0	13	13	34
600	6	10	13	37
Total	161	185	133	230
Average	23%	20.5%	19%	28.7%

The variation and moisture content of the soil has also a great deal to do with the amount of tassels, but it is almost impossible to put one's finger on the exact influence which it has. Fields are often spotted with tassels, some places having practically none, while in others as much as 50 per cent of the cane is tasseled. Our observation shows that exposed hillsides are more prone to tassel than protected hollows. There are also more tassels along the level ditches than farther away from same.

The effect of tasseling on the quality of the cane has been studied for the past several years, and we have prepared a table showing the quality ratio three and six months after tasseling. This shows a higher quality of cane in the non-tasseled than in the tasseled cane.

EFFECT OF TASSELING ON THE QUALITY OF CANE

Variety D 1135.

Three Months After Tasseling.

Tasseled Cane			Non-Tasseled Cane		
Brix	Sucrose	Purity	Brix	Sucrose	Purity
18.51	16.63	89.84	19.47	17.83	91.58
17.51	15.88	90.69	18.04	16.40	90.91
19.23	17.56	91.32	19.35	18.13	93.70
18.44	17.03	92.35	18.91	17.63	93.23
18.14	16.54	91.18	19.11	18.10	94.71
18.54	16.98	91.59	17.95	16.27	90.69
17.85	16.18	90.64	15.94	13.74	86.12
17.85	16.18	90.64	18.64	17.27	92.63
Total	146.07	728.25	147.41	135.37	733.57
Average	18.26	91.02	18.43	16.92	91.81

Six Months After Tasseling.

16.53	14.45	87.4	17.47	15.56	89.1
16.54	14.04	84.	16.01	14.05	87.7
17.25	15.51	89.91	17.91	16.26	90.79
17.73	16.18	91.25	17.68	16.19	91.57
18.77	17.05	91.84	18.47	16.82	91.07
18.86	17.61	93.37	18.55	16.94	91.32
16.45	14.47	87.96	16.85	15.24	90.45
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Total	122.13	109.31	625.73	122.94	111.06
Average	17.45	15.62	89.50	17.56	15.96
					632.
					90.34

Since tasseling halts the growth of the cane there is no doubt that the amount of cane produced per acre is less with tassels than without. As a great deal of the growth in this district is made in the winter months, when water is not a limiting factor, we feel that tasseling is not desirable. We have found that under certain conditions cane does not lala, consequently it dies out and there is a double loss. This condition occurs when the tasseling season is followed by a drop in temperature below the critical point at which cane will lala.

Tasseling can be, to a certain extent, controlled by intensive cultivation. A strong growing plant generally tassels less than one which is growing normally. A heavy dressing of nitrate of soda, applied just previous to the formation of tassels in the leaf sheath, which is around the last of August, followed by all the water required, will practically prevent tasseling.

We also feel that the opposite is true to a certain extent. From our experience in 1917 when the dry spell was of such intensity that the cane was practically dormant from March until the first of November, when good rains fell and things started growing, very few tassels appeared, as previously mentioned. In other words, it is an abnormal or a subnormal condition which has a check on tasseling.

Cane which is cut in January, February, March and April receives a special treatment to prevent excessive tasseling. In the case of young cane, it is preferable to force the growth ahead rather than to check same. Cane cut after the end of May and June requires no special care to prevent tasseling.

We do not feel that under any conditions cutting back of young cane is justifiable. Even though 50 per cent of the cane was to tassel and die out the remaining stand is more than sufficient to produce a normal crop. On an average we have in our cane fields about twice as much cane at 8 to 10 months as will be harvested, and whether we weed it out by means of tassels or by the survival of the fittest the ultimate results, we believe, will be about the same.

We are indebted to Mr. E. E. Naquin for the tables supplied above.

(CONTRIBUTION FROM F. A. PARIS, H. S. P. A. SUBSTATION, WAIPIO.)

- I. (a) 1. The first tassels were observed at Waipio on November 4, 1922. We noticed some on Honolulu Plantation on the 30th of October.
2. The last tassels appeared on December 20, 1922, but these never developed completely.
3. The heaviest tasseling was noticed during November.
4. Cold weather seems to cause an early tasseling. In Peru, for example, tassels are observed during cold years only.
5. Lower fields begin to tassel early.
6. H 456 and H 109 tasseled here earlier than D 1135, Badila came last and tasseled very slightly compared to other varieties, in fact, last year we could not find any Badila tassels among cane of about one acre. Our new seedlings behave very differently with regard to tasseling, some tassel very freely and some not at all, even when the cane is nearly mature.

(b) 7. Plant cane and ratoon cane on Oahu tassel in about the same proportion when conditions are favorable for it. Both have a tendency to tassel more at the higher elevations. On the Kohala coast where the lower fields suffer from drought more than the upper fields, the situation is reversed. In poorly drained soils the tasseling is very heavy. We noticed that cane growing in wet spots was tasseling heavily, while the surrounding cane situated on higher land was not tasseling at all. Cane exposed to wind tassels more for two reasons, the quick evaporation of the moisture in the soil causing irregular growth of the plant, and the disturbing effect of the wind on the root system: the stalks are pushed over by the wind, the roots broken or the contact between them and the soil becomes imperfect, thus preventing a good circulation from the roots to the upper part of the plant and insufficient nourishment. On the Kohala coast where the wind is blowing hard for months at a time the tasseling on the most exposed spots was very heavy. One of the reasons for the tasseling being heavier on the edges of our fields here, is the disturbing effect of the wind.

8. Climatic conditions are partly responsible for different amounts of tasseling. A cold or very dry year will increase the amount of tassels, but a very favorable year for growth may bring a well cultivated cane field quicker to full development and in that case we may have also a high proportion of tassels in the autumn, as a normal end of an exuberant existence.

(c) 9. If the cane is cut soon after tasseling, especially after heavy tasseling, the sucrose content in that cane will be higher than in cane with no tassels or very few, as tasseling puts a stop to further development of the stalks, creating early maturing. But if that cane is left for a few months in the field and the rainfall is heavy the cane will lala, and if it is recumbent, or if the stand is thin, many suckers will grow and reduce greatly the sucrose content. Therefore the earlier we cut the cane after tasseling the better, and the smaller the losses compared to cane which has not tasseled.

Twenty-five per cent tasseling can cause a loss in sugar of about a hundred and twenty-five pounds.

Fifty per cent tasseling, two hundred and fifty pounds.

These losses are calculated on the basis of 0.5 ton of sugar per acre per month and taking a loss of one month's growth due to tasseling, the cane being 16 to 17 months old.

10. I do not see any reason for favoring tasseling even in cane within 6 months of harvesting, the lalas likely to grow after the cane has tasseled make the cutting more difficult, their juice is of inferior quality, a good many are broken off and are left in the field at the time of harvesting. After a heavy tasseling the suckers are likely to be numerous, especially on good soil, they spoil the juice very much.

(d) 11. Tasseling, as we mentioned before, is the normal end of a very normal development of a plant when it takes place with heavy cane from 18 months to 2 years old, but when it comes earlier it is always the result of some disturbance of the vegetation caused by climatic conditions, or imperfect cultivation or diseases and pests. The more perfect the conditions the less tasseling.

12. Fertilization is one of the important factors we possess to control vegetation in our fields, especially when fertilizers are used in a soluble, concentrated form. We can counteract the bad effect of unfavorable climatic conditions, correct insufficient fertility in our soils, create uniform conditions. By the intelligent use of fertilizer tasseling can be reduced to a negligible proportion. We noticed often a weakening of the vegetation in cane from a year to 14 months old; the quantity of fertilizer

applied was not sufficient to carry the crop through in one uniform swing; the cane under this condition will tassel heavily.

At Waipio the tasseling in our 15 to 17 months old cane, plant or ratoon, is never above 15 per cent, and even less in our best fields. This year we have 5 to 7 per cent tassels in plant cane and up to 11 per cent in third ratoons. We expect yields from 12 to 14 tons of sugar per acre and more. The fertilization varied from 300 to 350 pounds of nitrogen per acre and in some cases sixty pounds of phosphoric acid, both applied during the first year.

- (b) Irrigation influences the tasseling in about the same proportion as fertilization. The proportion of moisture in the soil should be kept near the ideal for the maximum growth of the cane; under our conditions that proportion amounts to between twenty-five and twenty-six per cent, and to keep it up during the summer months we have to irrigate about every seventeen days. Light irrigation from one and one-half to two-acre inches at a time, given every two weeks, seems to be better than heavy irrigations from four and a half to six-acre inches given every three weeks. We estimate that the gain in favor of a light irrigation amounts to about a ton of sugar per acre, and the quantity of water used will be less. The cane requires at least a hundred and thirty-acre inches to get up to maturity. During the months of August and September the irrigation ought to be rather more frequent, as a shortage of moisture during that period would cause a heavier tasseling.

We have at Waipio a few plots which have not been fertilized for the last ten years. They were planted in 1921 with H 109 and they will yield about twenty-five tons of cane per acre against a hundred to a hundred and ten tons from the adjacent fertilized plots. The irrigation was uniform for the fertilized and unfertilized sections. The tasseling in the unfertilized cane amounts to about one hundred per cent against about fifteen in the fertilized cane.

It shows that water and fertilizer must be combined to obtain maximum results and with regard to tasseling, adequate fertilization is probably even more important.

- II. 13. January is a very bad month for starting a crop of cane. It is generally a wet, cold month, preventing any cultivation. Harvesting during that month should take place in fields which are going to be plowed up. From February to June the conditions which will cause tasseling are the same: Exceptional and unfavorable climatic conditions like cold or heavy winds, excess of moisture, insufficient fertilization and irrigation. The poorer the soil and the more unfavorable the situation of the field the more important will these conditions be. A late hilling up and an excessive hilling up will also disturb the root system to such an extent that the cane will suffer an irreparable check at the beginning of life which will cause tasseling. Suckers left over from the previous crop will tassel. An imperfect irrigation system is often responsible for a very irregular stand of cane and heavy tasseling in young cane.

Tassels are more numerous along ditches and on the periphery of a field, especially in ratoon fields. We put it down to stools being high above the irrigation furrow or in an unfavorable situation in regard to irrigation. On the outside fast growing canes are likely to fall over, the roots being disturbed and the circulation in the stalk hindered; naturally any of these conditions would check the growth and provoke tasseling. Outside stools stool more, they go on stooling for a longer period, gradually due to the fact that some of the early shoots are weakened and they tassel. In ratoon fields the trash is pulled up on the periphery of the field when the trash is burned after harvesting, the out-

side lines have been stripped by the irrigation gang and there the trash is scarce, so that many of the young suckers are not killed by the fire and they come up in the next crop and tassel early.

14. Under our actual conditions here and the amount of knowledge we possess, early tasseling can be reduced to such small proportions that from a business point of view, cutting back should not take place. We believe that in the past the importance of tasseling as a yield reducing factor was greatly exaggerated. We do not think that counts were made in the field to determine the exact proportion of tassels. A twenty-five per cent tasseling field will look, from a distance, like having one hundred per cent tassels, and as often put down as such before, according to old hands.

At Waipio during 1921, our short ratoons started from March to May did not tassel at all nor did the cane planted in March, April and May. On the plantations, tasseling was very slight, too, where the cane was not cut back. This year we counted, in a field started in March, an average of 24,720 sticks per acre with 115 tassels per acre, giving 0.46 per cent. In cane cut in April and May we have an average of 26,880 sticks per acre at one place and 30,750 sticks per acre at another place with 0.42 per cent and 0.374 per cent tassels per acre respectively, the number of tassels was from 115 to 120 per acre in both cases. In cane planted in March, 1922, we have practically no tassels. This field consists of eleven acres of pali land of poor quality and the soil in many places is very shallow. The heaviest tasseling of short ratoon cane we counted on a plantation this year was 23 per cent. The cane was fertilized rather late for the first time, and cut very early in the year. In another case, noted on one of the plantations, the cane which was not cut back in a field, the remainder of which was cut back on the 10th of July, only tasseled to the extent of 0.4 to 0.5 per cent. (About 120 tassels per acre in cane running from 24,000 to 25,000 sticks per acre.) The field was irrigated fairly regularly every three weeks after harvesting, which took place in April. The fertilizer was applied late, July (1,000 pounds high grade per acre). The stalks coming up after cutting back are very small on account of an excessive stooling, the future of that cane is less promising than the not cut back. The tonnage now is very much superior in the last mentioned.

15. In the case of not cutting back, care is required so as to prevent any check in the growth of the cane from the time of starting up to the time the tassels are likely to be formed, especially during the months of July and August, the young cane must be in good growing condition, well supplied with fertilizer and water. If the crop is started early in the year two doses of fertilizer should be applied up to August, and in the case of short ratoons the full dose should be in by the end of September.

The earlier a field is irrigated and fertilized after harvesting the better it is, not only to gain time during the best growing period of the year but also to provoke an early stooling and a quick shading of the soil, preventing in that way the growth of weeds and conserving tilth in the soil.

At Waipio we obtained very good results through applying fifty pounds of nitrogen in plant cane about six weeks after planting, in ratoons immediately after the first irrigation. Six weeks later the second dose of one hundred pounds of nitrogen is applied, followed by a third dose of one hundred to one hundred and thirty pounds of nitrogen when the cane is from five to six months old. In long ratoons and long plant the third dose comes early in the second year and varies in quantity according to the stand of the cane.

Complete fertilizer against nitrogen only had no restraining influence on tasseling. In ratoon fields the breaking up of the ridges in between the cane rows and a slight hilling up may favor the growth of the cane and reduce slightly the number of tassels. Paper mulch did not influence tasseling in either way.

There is nothing definite about the time fertilizer should be applied. It is up to the man to watch the cane and feed it according to the needs so as to keep the vegetation going at full speed, as long as the climatic conditions permit it. An early start and a good start leaves scope for improvement, and increase of yield, but any check due to late fertilization is irreparable, the more so when it happens a few months after the crop was started. We should certainly rather neglect canes getting near the end of their life or a field not having been started, than young cane a few months old and in good shape. The term "feeding the baby" applies to cane as well as it applies to animals, and the art of feeding plants is as delicate as the feeding of valuable stock. Both require a thorough knowledge and a keen observation. We have the feeling that as far as man is concerned a crop of cane is made during the first seven months and it is only through intensive application of our best cultivation methods during that period that success is obtained.

16. To calculate the loss through young cane tasseling during the first year, we base our calculations on the production of sugar of 0.5 ton of sugar per acre per month, an average which ought to be considered normal under good conditions in our district. Taking one of the worst cases against not cutting back, say 50 per cent tassels, in cane cut at the beginning of February, we get the following figures:

Losses per Acre.

		Cut back July 10	Not cut back
From February to July....	Irrigation Wages	\$15.00	\$15.00
	Water	28.00	28.00
	Cultivation	3.75	3.75
	Cutting Back	2.00	.....
	Rent, etc.	5.00	5.00
		<hr/>	<hr/>
		\$53.75	\$51.75
Sugar loss:			
5 months at 0.5: 2.5 tons at			
\$110		\$275.00	.....
9 months at 0.25 ton: 2.25			
tons at			\$247.50
Balance in favor (per acre)			
not cut back.....			29.50
		<hr/>	<hr/>
		\$328.75	\$328.75

Taking cane cut in April and tasseling up to 25 per cent in November the loss, in sugar per acre would be, if the cane was cut in August of the following year, 1.12 tons. If cut back in July we should lose three months at 0.5 ton of sugar per acre per month, or a total of 1.5 tons sugar, plus expenses of irrigation, etc., up to the time of cutting back.

In each case cutting back is proved to be a loss, and that without taking into consideration the better results obtained with a crop started early. Cutting back would also render a short cropping impossible, an opportunity which is closely connected with improved methods of cul-

tivation and the development of fast growing and early maturing strains of cane. The possibilities which shorter cropping periods offer to the industry are important, they have already been mentioned by the Station.

Comparing cutting back with not cutting back during a series of three crops we get the following figures:

Not Cut Back	Cut Back
Field started February, 1922	Same field started July 10, 1922
cut August, 1923	cut March, 1924
cut April, 1925	started July, 1924
cut August, 1926	cut April, 1926
	started July, 1926

In summing up the yields through the years we come to a total of 26.0 tons of sugar per acre for three crops with the not cut back system against 20.0 tons per acre for two crops when cutting back, a difference of 6.0 tons in favor of the former system. We have to add to that the cheaper cost of production connected with the non-cutting back system, a gain which would more than pay for the higher harvesting expenses. We are here very conservative in the estimation of yields for the short crops.

With regard to the importance of early fertilization we would like to mention here the rapidity with which young cane in perfect growing condition will absorb high doses of nitrogen, and the increase of growth obtained when that element is supplied in large quantities during the first growing season.

We noticed repeatedly, that the cane about three months old which had already been fertilized with fifty pounds of nitrogen and was growing fast, would absorb within five or six weeks a hundred pounds of nitrogen, at least past that period the color of the cane was slightly fading, and the growth beginning to slacken. It is only when we get to about two hundred or two hundred and fifty pounds of nitrogen per acre that the effect seems to last longer.

In short ratoons sixteen and one-half months old we measured canes 21' 6" long, which means a weekly average growth of 3.58" up to the day of harvesting, the cane having been seventy days without irrigation previous to harvesting. The average weekly growth of several other stalks measured in the same field was 3" and above. The stalks measured were all primaries, but taking an average of four stalks per stool and 24,000 stalks to the acre, sixty weeks old, a 3" growth a week would give us yields of one hundred and forty-four tons of cane per acre or .960 tons of sugar per acre per month. These results show the possibilities for cultivation of creating such ideal conditions that these high yields will be realized over a large acreage.

Grouping of the best fields in a number 1 zone or section for intensive treatment, permanent plant tests, shorter cropping, weekly growth measurements and moisture determinations in the soil, must come in for such fine work. In making the field work intensive and accurate and so productive, how much more interesting, fascinating it becomes from an agricultural, from a business point of view. It will be a great stimulus for a man to have more and more the feeling that the crop is his.

(CONTRIBUTION FROM H. P. AGEE.)

Without attempting to take data last season, and answer your questions in detail, I give as follows the general impressions which I hold on the subject of cane tasseling:

Time of Tasseling: Climatic conditions no doubt have a pronounced effect on tasseling. In Hawaii, tassels appear in November; in Cuba, in January. I doubt if elevation *per se* has influence on tasseling, but climatic conditions resulting from different elevations undoubtedly do. This is shown very clearly at Pioneer Mill Company, where the low areas do not tassel, while those at 50 to 100 feet elevation do tassel. The time of tasseling of different varieties is somewhat different. The Japanese cane (Uba) and Badila tassel later than most varieties. Most of our varieties, however, tassel at approximately the same time.

Quantity of Tassels: Tasseling is apt to be heavier in ratoon cane than in plant cane. Anything affecting the tendency of the cane to mature influences the amount of tassels. This is illustrated very clearly by the practice of cutting back. Canes starting in July are not big enough to mature tassels. Canes started a month or two earlier have a tendency to tassel. We may offset this tendency by forced growth from irrigation and fertilization. If we irrigated and fertilized heavily during the early part of the summer and then allowed a check to come about the month of September, tasseling would be expected. Any check during the growth of cane during August or September tends to increase the number of tassels provided the cane is big enough to set them.

The formation of tassels, that is the maturing of the cane plant, in the fall or winter, is due, in part, to cooler temperatures and to decreased sunlight. Cane in upper Manoa Valley shows a tendency to tassel earlier than here at Makiki. I think this is due to the fact that the sunlight in the valley is cut off by the surrounding mountains. 1922 was a year with a large amount of tasseling on Oahu. I attribute this, at least in part, to the dry summer and the difficulty in keeping cane well irrigated.

Effect of Tasseling: An experiment with Lahaina cane at Oahu Sugar Company several years ago showed benefit from not cutting back when there was 16 per cent of tassels. As to whether benefit or loss will result from a given per cent of tassels depends upon the amount of growing time that one would sacrifice by cutting back. No field should be cut back without leaving inserts to see what the effect would have been from not cutting back. Until such experimenting becomes common and much data is accumulated, the question of whether or not to cut back is one of guess work.

I have no data on your Question 10, but I should not be greatly concerned if a field tassels that is to be harvested within six months.

Cause of Tasseling: Maturity, which is brought about by checking growth, from decreased temperatures, decreased light, and which would also be fostered by such factors as decreased irrigation or decreased fertilization at the crucial time. We have positive results for the Waipio Substation and the Makiki Plots, Honolulu, showing that tasseling can be reduced to a negligible amount by fertilization and irrigation.

General: The benefits and losses from cutting back must be worked out for each part of each plantation. The results must not be judged on the number of tassels, but on the sugar ultimately produced. Ten to twenty per cent of the sticks tasseling might be a very discouraging sight, but we have no data to show that this results in a lower sugar yield. Under average conditions, perhaps 30 per cent of tassels would be an even break between no loss and no gain from cutting back. But here I am guessing when we should be experimenting.

Report of the Committee on "Colloids"

THE RELATION OF MILL JUICES TO THE MILLING PROCESS*

By J. D. BOND

According to Zsigmondy¹ "cells, their contents and membranes consist of colloids. The sap of plants is intrinsically a colloidal solution." Cellulose has been defined as a sponge-like structure of colloidal particles held together by certain "unused residual affinities."²

Moreover, "the colloids in juices form a very complex system in which the dispersion medium is evidently water. Proteids, polyphenol compounds and related coloring matters, clay, fiber and coarse dispersoids are present. Moreover adsorption complexes are probably formed.³ It is therefore evident that in the milling process we are dealing with substances primarily colloidal.

Sugar manufacture as an industry producing a vegetable product deals mainly with emulsoids. Patents have been taken out on electro-osmotic purification but no definite information is to be had.⁴ Norris⁵ found that material from juices was retained by Chamberlain filters.

According to Deerr⁶ there is a separation of colloids in juices by heat at about 190° F. The filtration of cane juice in the cold removes from the system the same substances as are eliminated by a rise of temperature to not less than 190° F. It was concluded that colloids in cane juices are irreversible with respect to temperature, reversible to acids and alkalies and are not coagulated by small quantities of electrolytes. These colloids are emulsoids and are negatively charged. More than half of the precipitate obtained in the clarification consists of matter originally present in the colloid state.

In spite of the clearness of filtered, clarified juice, impurities as colloids are present. The fact that excess lime causes more precipitate to form is no proof that the action is strictly chemical because the sulfitation and carbonation processes can be reversed in the laboratory with no change in effect. The acidity of raw juice is reduced by boiling with kieselguhr, most probably due to adsorption. This is true also of decolorizing carbons, but the effect is four or five times as great. Colloids are not entirely removed from juices by kieselguhr, though it gives a clear filtrate, dark in color. Addition of clay or similar colloids which may coagulate other colloids, like proteids, has been suggested.⁷

Colloidal organic silica compounds have been suggested as the cause for poor defecation. These are claimed to be destroyed by superheating before liming.⁸

* This account includes (a) a brief review of available literature on colloids of the sugar industry; and (b) an account of some original work attempted at the Ewa laboratory.

¹ Chemistry of Colloids, p. 5.

² Paper 25, 700-703 (1919) Minor.

³ La. Bull. 173, p. 7.

⁴ I. S. J. 23, 400 (1921) Dedek.

⁵ I. S. J. 21, 71 (1919).

⁶ I. S. J. 18, 502 (1916).

⁷ La. Bull. 173, pp. 4-6.

⁸ I. S. J. 23, 579 (1921) Muller.

The clarification of syrup is based on the phenomena of adsorption by colloidal substances.⁹

Sugar may be hindered in crystallization by protective colloids and this is practised in the manufacture of some candies.¹⁰ A concentrated solution of sugar in water will prevent the precipitation of many inorganic salts including, of particular interest, calcium silicate, lime salts and hydrous oxides of iron. Invert sugar is about seven times as effective as sucrose in holding up hydrous ferric oxide.¹¹

Colloids are apparently the source of many difficulties in filtration and of viscous low grades. Inboiling tends to retard crystallization and increase viscosity due perhaps to colloid behavior. Concentrated sugar solutions exhibit the Tyndall effect.¹²

Helderman and Khainovsky¹³ from a study of the viscosity of molasses, conclude that the colloids present exert a very great influence. By the use of Norit, they obtained a juice apparently colloid-free. In all cases the quantity of colloids was diminished by treatment with adsorption material. Protective action of colloids in withholding crystallization of inorganic salts, was observed.

"The use of lime alone removes colloids which are not removed by filtration of the juice with kieselguhr. About one-half the amount of total colloids was found in juice that had been limed 1.0—0.2 cc. acidity. From the standpoint of removal of colloids, liming to a low degree of acidity, being careful not to over-lime, is probably good practice. Weights of colloids in syrup (from sulfitation process) were reduced approximately one-half by kieselguhr filtration."¹⁴

The literature contains a considerable number of instances in which attention is called to the problems in the sugar industry connected with colloids. Schneller¹⁵ mentions the problem; Peck¹⁶ suggests that colloids in juice are tannins, albuminoids and pectin bodies; Zerban¹⁷ suggests protein cleavage products; Plausom¹⁸ has devised a method of ultrafiltration which has, however, been adversely criticized; Brewster¹⁹ has done some work on the effect of decolorizing carbons; and many others. The Bureau of Chemistry is at present engaged in a study of the entire subject as to the presence and effect of colloidal matter in sugar house juices and products. Before the next meeting of this Association some of their work will no doubt have been published.

We present in the following a brief account of some work carried out during the grinding season of 1923. No attempt will be made here to discuss the chemical nature or the effect of colloidal matter on our manufacturing process. Rather we will attempt to show the relation of colloidal matter to the well known char-

⁹ J. Am. Chem. Soc. 27, 86-104 (1905) Noyes.

¹⁰ Jerome Alexander from Manual of Industrial Chemistry, Rodgers, p. 1147.

¹¹ Applied Colloid Chemistry, Bancroft, p. 168.

¹² I. S. J. 23, 400 (1921) Dedek.

¹³ I. S. J. 24, 89 (1922).

¹⁴ "Report of Work on Some Cane Sugar Manufacturing Problems"—Bureau of Chemistry, Washington, D. C., through courtesy of Dr. H. S. Paine, 1921.

¹⁵ La. Planter 56, 44 (1916).

¹⁶ I. S. J. 21, 70 (1919).

¹⁷ I. S. J. 23, 32 (1921).

¹⁸ I. S. J. 23, 680 (1921).

¹⁹ J. Ind. Chem. Eng. 13, 10 (1921).

acteristics of mill juices. It must be remembered that our conditions are limited to those obtaining at the factory of the Ewa Plantation and conclusions may or may not apply in other cases.

In any consideration of the milling plant from the standpoint of the boiling house, the most obvious fact is the steady decrease in juice purity from mill to mill. Deerr²⁰ assigns the fact entirely to differences in purity between rind and pith juices.

*In our work, cane was taken from the cars on the track and sampled as fairly as possible as to top, middle and bottom of the stalk. The variety was H 109, canes were sound, weighed from 3-4 kilograms per sample and the tests cover a period of several months. After separation into (a) rind and (b) pith and nodes, the material was reduced in the Athol chopper, weighed and the juice expressed in the familiar hand laboratory press used for the routine determination of fiber in cane. No inconsiderable pressure was exerted since we were able in the same way to express about 1 per cent of residual juice from bagasse. The data is given in Table I.

TABLE I.

	Tests				App. Purity	Gravity Purity	% of Cane	% of Fiber	Fiber % Ash
	Averaged	Brix	Pol'n.	Sucrose					
Pith....	9	20.52	18.78	18.94	91.52	92.30	55.65	6.33	1.75
Rind....	9	21.40	18.50	18.72	86.45	87.48	44.35	21.46	1.63

The maximum difference between the apparent purities of pith (the term "pith" will hereafter [and in Table 1] in our usage include nodes) and of rind juices was 8.1. The lowest observed purity of rind juice was 81. These values are no doubt too high for ordinary practice, but the chief point is the difference in apparent purity between pith and rind juices, which we find to average 5.07 in Table 1. From Table 2 following, the difference between crusher and last mill juice purities for maceration milling is 20.12 points; for dry crushing, 7.86; average for the 1923 crop from control figures, 21.17, with crusher juice purity 84.66.

Table 2 contains data on mill tests. Juices were collected from the discharge rolls of each mill in sequence and analyzed immediately.

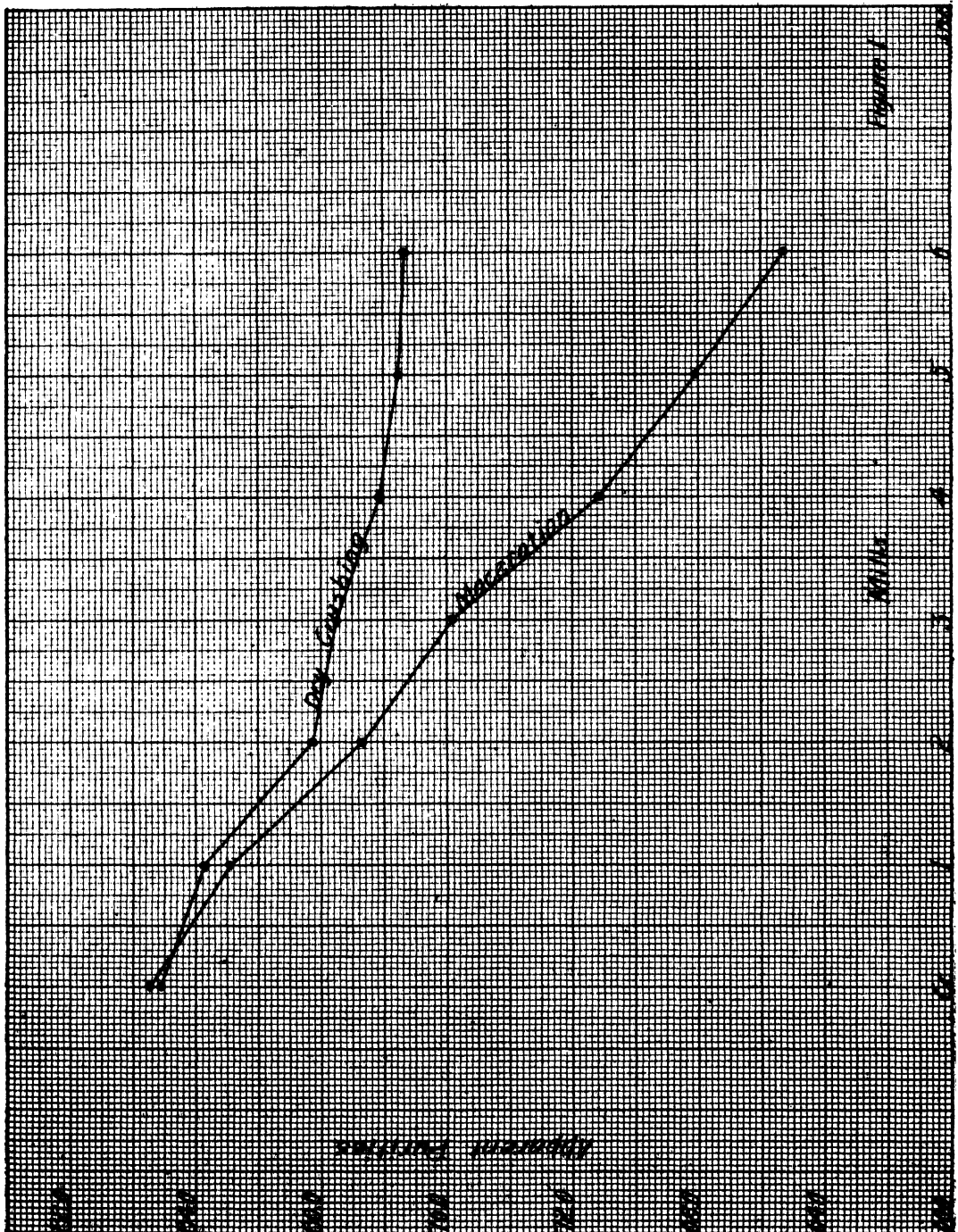
TABLE 2.

Mills	Dry Crushing						Maceration					
	Tests	App.				Grav.	Tests	App.				Grav.
	Avgd.	Brix	Pol'n.	Sucr.	Purity	Purity	Avgd.	Brix	Pol'n.	Sucr.	Purity	Purity
Cr.	4	18.95	16.13	16.39	85.13	86.49	12	18.05	15.42	15.67	85.44	86.84
1.	"	18.64	15.62	15.81	83.79	84.82	"	17.12	14.19	14.40	82.91	84.12
2.	"	19.05	15.28	15.47	80.21	81.22	"	11.21	8.82	8.92	78.71	79.54
3.	"	19.06	15.15	15.27	79.49	80.13	"	8.08	6.13	6.17	75.81	76.34
4.	"	18.68	14.59	14.73	78.11	78.84	"	4.08	2.90	2.94	71.18	72.04
5.	"	19.08	14.80	14.96	77.56	78.41	"	2.72	1.85	1.88	68.04	68.96
6.	2*	18.72	14.46	14.62	77.27	78.10	"	1.49	0.97	0.99	65.32	66.44

²⁰ Cane Sugar, pp. 243-247.

* Two tests only in this series yielded juice in the last mill. For Table 2, the data given for this mill have been calculated from the two tests by proportion.

It is difficult to understand how the purity of last mill juices can be accounted for by rind juice alone. If this were strictly true, dry crushing tests should demonstrate the point quite as well as maceration tests. Moreover, in our cane tests we should have observed at least some instances of very low rind juice purity. We are, of course, considering juices as primarily molecularly dispersed systems, independent of the colloidal nature of fiber. It is reasonable to suppose that the impurities of last mill juices are introduced from rind fiber for the most part since it comprises about 75 per cent of cane fiber.



The curves of Fig. 1 show graphically that we cannot definitely limit the purity of last mill juice in actual practice, but that apparently the purity is dependent upon the treatment of the fiber in the milling process. We have shown in data, which we will not include here, that dilution effects cannot contribute toward the low purity of mill juices, nor, in normal practice is there deterioration of juices.

In Table 3, we have calculated various ratios from our milling data.

TABLE 3.

Mills	Dry Crushing				Maceration.			
	Glucose	S. N. S.	Glucose	Grav Pur.	Glucose	S. N. S.	Glucose	Grav. Pur.
	Sucrose	Brix	S. N. S.	— App. “	Sucrose	Brix	S. N. S.	— App. “
Cr.	6.65	13.51	42.58	1.36	6.13	13.16	39.0	1.40
1.	6.46	15.18	36.04	1.03	5.93	15.88	29.9	1.21
2.	7.04	18.78	30.44	1.01	6.73	20.46	25.5	0.83
3.	7.43	19.87	30.08	0.64	7.55	23.66	23.9	0.53
4.	7.55	21.16	28.10	0.73	8.24	27.96	23.0	0.86
5.	6.93	21.59	25.24	0.85	7.79	31.04	18.6	0.92
6.	6.80	21.90	23.42	0.83	6.82	33.56	13.0	1.12

The ratios are, of course, all multiplied by 100. By “S. N. S.” we mean **solids not sucrose**.

It will be noted that the glucose ratio drops from crusher to first mill due, no doubt, to the first expression of juices from soft tissues which are high in glucose ratio.²¹ On further milling, the glucose ratio increases steadily up to and including the fourth mill, after which it drops rapidly through the two succeeding mills. The rise in the ratio may be accounted for by the increasing amount of rind juice expressed in relation to total juice. We know that the glucose ratio of rind juices is somewhat higher than that of pith juices. The drop is, however, not so easily explained unless it be due to selective extraction.

Though S. N. S. per cent Brix is virtually constant in Table 3 for mills 4, 5 and 6 dry crushing, the difference between gravity and apparent purities increases and glucose S. N. S. falls. It would thus appear that while reducing substances are extracted, impurities containing optically active substances are developed. These points are further demonstrated in the case of maceration milling.

The large differences in gravity and apparent purities in the first mills are due probably to levulose in the juices of the softer tissues of the cane, which however, is apparently selectively extracted.

Our data is of course entirely indirect. Direct proof will be difficult. Obviously, these points may be truly characteristic of rind fiber, but this does not alter its significance as far as the milling process is concerned.

In Table 4 are given some data on the ash relations of mill juices. For raw juices, the cotton-filtered juice was taken; for clarified juice, the kieselguhr filtered juice, 30-50 grams of the juices were weighed out in small evaporating dishes, dried at 110° C. and the normal ash determined in the same dishes, using the ash muffle.

²¹ Cane Sugar and its Manufacture, Prinsen Geerligs, p. 83.

TABLE 4.

Mills	Dry Crushing				Maceration			
	Raw Juices		Clarified Juices		Raw Juices		Clarified Juices	
	Ash % Brix	Ash % S.N.S.	Ash % Brix	Ash % S.N.S.	Ash % Brix	Ash % S.N.S.	Ash % Brix	Ash % S.N.S.
Cr.	2.30	17.25	1.41	10.20	2.45	18.60	2.19	16.60
1.	2.88	19.47	2.78	15.93	2.84	19.00	2.98	24.48
2.	3.45	17.47	3.20	15.54	3.86	20.38	4.01	21.30
3.	3.59	17.36	3.38	15.50	5.11	23.30	5.57	25.25
4.	3.85	17.61	3.75	16.51	6.02	20.79	4.07	18.70
5.	3.93	17.45	3.78	15.36	6.46	19.31	4.48	16.74
6.	3.98	17.04	3.13	13.72	8.21	26.10	6.57	23.56

The above data are taken from two complete dry crushing tests and four maceration tests.

A marked difference in ash relations between dry crushing and maceration juices will be noted. The Ash per cent S. N. S. of dry crushing juices is practically constant, whereas Ash per cent Brix increases steadily. In direct contrast, Ash per cent Brix of maceration juices increases rapidly reaching a maximum at the last mill. Ash per cent S. N. S. is variable. These results are moreover carried through to the clarified juice, though somewhat obscured in cases, due to lime.

These facts further substantiate our contention that the characteristics of last mill juices are not intrinsic, but are due to heavy milling in what is practically a water medium.

In Table 5 we give the colloid relations of mill juices. All of the material of the raw juice passing through a cotton filter about one inch thick and not settling after one hour at rest, was classed as colloidal. Obviously, this is not strictly true, but as a means for comparison and for rapid working (which is essential) this procedure was satisfactory. All clarified juices were filtered through kieselguhr after liming the raw juice alkaline to phenolphthalein in the cold and heating to the cracking point. These tests were planned only to give maximum coagulation of colloidal matter. Juices were dialyzed in collodion sacks for 48-72 hours in tap water, followed by 48 hours in distilled water. The colloid solution including coagulated matter was then evaporated on the water bath, finally dried in small evaporating dishes to constant weight and weighed. Weights of dried colloids checking within 5 per cent of each other were accepted.

TABLE 5.

Mills	Dry Crushing				Maceration			
	Raw Juices		Clarified Juices		Raw Juices		Clarified Juices	
	Colloids % Brix	Colloids % S.N.S.	Colloids % Brix	Colloids % S.N.S.	Colloids % Brix	Colloids % S.N.S.	Colloids % Brix	Colloids % S.N.S.
Cr.	1.93	14.63	0.79	5.92	1.88	14.74	0.49	4.07
1.	2.33	15.15	0.67	3.96	2.03	12.71	0.64	4.33
2.	2.36	12.40	0.92	4.78	3.19	14.92	0.98	5.25
3.	2.85	14.29	1.24	5.90	4.83	19.90	1.04	4.55
4.	2.85	13.06	1.25	5.71	8.00	28.53	1.24	4.84
5.	3.00	15.67	1.43	5.97	8.93	28.63	1.48	4.68
6.	3.10	13.27	1.25	5.49	11.87	32.82	2.20	5.89

The above data are taken from three dry crushing tests and nine maceration tests.

Colloids per cent S. N. S. are fairly constant for raw dry crushing juices whereas for raw maceration juices they increase rapidly and exceed, in the last mill, the percentage in the corresponding dry crushing juice by more than 100. Though the two juices are distinctly different as far as colloids in raw juices are concerned, they are comparable in the clarified juices. It is interesting to note, then, that maceration milling actually does increase the impurities in juice to a considerable extent. Since cane fiber is colloidal in nature, it is not unreasonable to expect that impurities, if they are added from the fiber, also be colloidal to some extent. ✕

Colloids are added as a result of mechanical action alone on the fiber, in the presence of a suitable medium, in this case water; and as a result of the breaking down of cell walls followed by flushing with water. This offers a very efficient means for the extraction of protoplasmic matter and other colloidal material confined normally within the cell wall. That colloids may be prepared from cane fiber may readily be demonstrated in the laboratory by continued grinding of prepared bagacillo in the presence of water. Furthermore, from a purely logical viewpoint, there is no reason to believe that the process of milling does not produce particles of fiber of all degrees of subdivision. A considerable amount of fiber from dried bagasse may be dusted through the finest screens. ✕

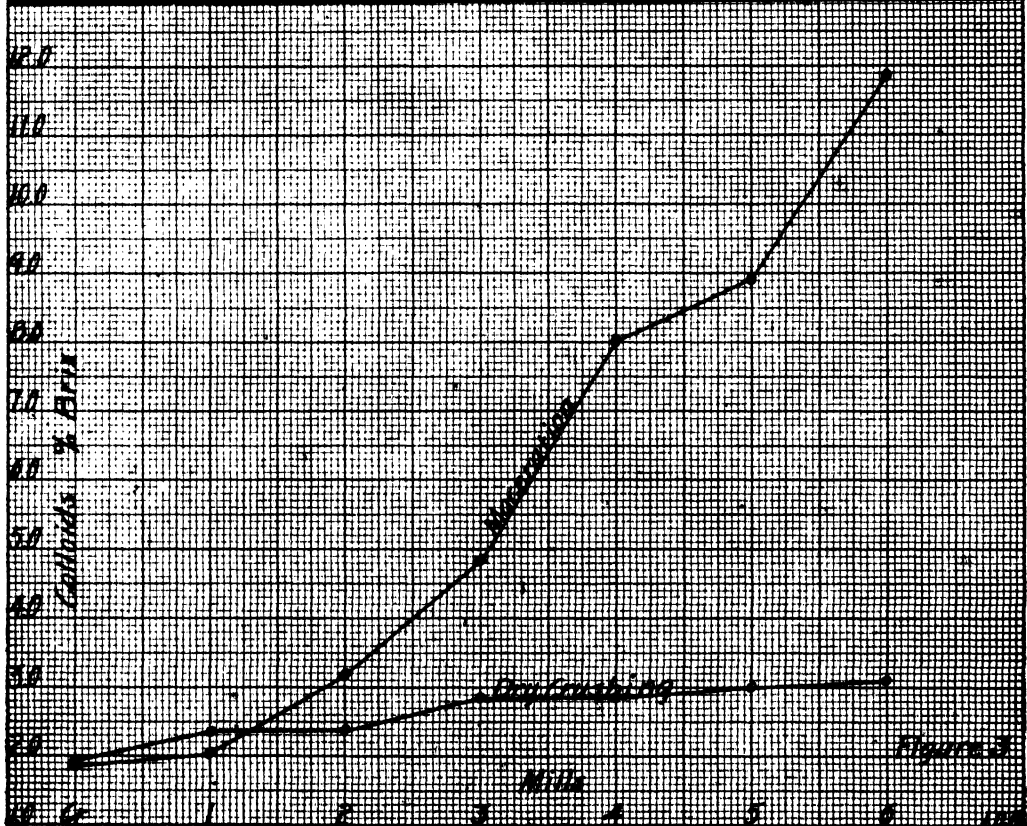
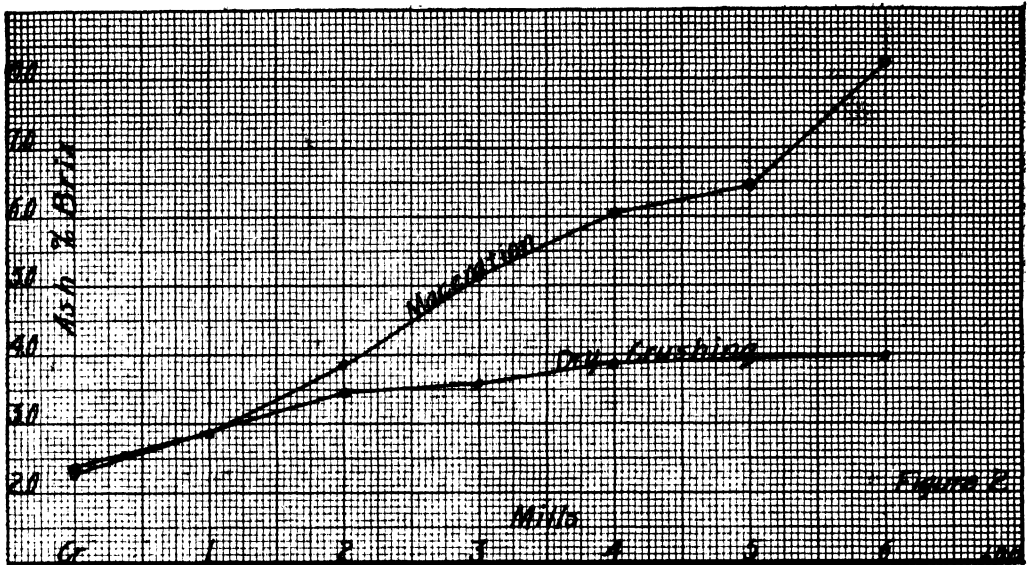
In one test, Colloid Ash per cent Total Ash in mill juices varied from 6.5 to 16.0 in the raw juice, but dropped in clarified mill juices from 1.1 to 7.2. It increased steadily in the clarified juice throughout the milling process. In the raw juice we may expect soil particles introduced with the cane, which, too, accounts for the high ash content. Colloid Ash per cent Brix varied in the raw juice from 0.23 to 1.07. This being the case, we may correct the gravity purity of juices for both ash and colloids without any considerable error. The figures, will of course be true only in a general way since solids were not determined by drying, but they will show the relative importance of ash and of colloids on the purities of juices. These calculations are given in Table 6.

TABLE 6.

Mills	Dry Crushing			Maceration		
	Gravity Purity	Grav. Pur. Plus Colloids % Bx.	G. Pur. Plus Coll. % Brix Plus Ash % Brix	Gravity Purity	Grav. Pur. Plus Colloids % Bx.	G. Pur. Plus Coll. % Brix Plus Ash % Brix
Cr.	86.49	88.42	90.72	86.84	88.72	91.17
1.	84.82	87.15	90.03	84.12	86.15	88.99
2.	81.22	83.58	87.03	79.54	82.73	86.59
3.	80.13	82.98	86.57	76.34	81.17	86.68
4.	78.84	81.69	85.54	72.04	80.04	86.06
5.	78.41	81.41	85.34	68.96	77.89	84.35
6.	78.10	81.20	85.18	66.44	78.31	86.52

We have here demonstrated that the juices of dry crushing and of maceration tests are actually comparable if colloids and ash are considered. The increased ash and colloid content of last mill juices can then only be derived from the fiber.

The marked similarity in behavior of both colloids and ash in dry crushing and maceration milling may be noted more clearly in the accompanying graphs, Figs. 2 and 3.



We have noted in dealing with dry crushing juices that those from the last three mills gave considerable difficulty in filtering, apparently irrespective of the amount of lead subacetate added. Indeed it often required a period of 3-4 hours

before sufficient juice could be obtained for a sucrose determination. The clarified, kieselguhr filtered juice of these mills was seldom brilliantly clear as was invariably the case with the earlier mills. Some difficulty is often experienced in routine control work in filtering the juice of the last mill, but does not compare with that obtaining in the case of dry crushing juices. It will be interesting to note Colloids per cent Juice as tabulated in Table 7.

TABLE 7.

Mills	Colloids % Juice.		Colloids % Juice.	
	Dry Crushing		Maceration	
	Raw Juices	Clarified Juices	Raw Juices	Clarified Juices
Cr.	0.39	0.16	0.34	0.10
1.	0.46	0.14	0.35	0.12
2.	0.47	0.17	0.36	0.12
3.	0.57	0.24	0.39	0.09
4.	0.61	0.21	0.35	0.06
5.	0.56	0.28	0.25	0.05
6.	0.66	0.26	0.18	0.04

The Colloids per cent Juice of dry crushing juices are thus seen to be considerably higher in the juices of the last mills than those of the earlier mills. The condition is, however, reversed in the case of maceration juices. It would thus appear in a qualitative way that the filtrability of juices is dependent not so much on the weight of colloidal matter present as upon the nature of these colloids. A case in point is the difference in filtrability of dry crushing juices in the third and fifth mills with the colloid content practically the same. Furthermore, in maceration milling, the last mill juice is the most difficult to filter, yet it contains the lowest percentage of colloids on juice.

The relations between residual and mill juices should develop our viewpoint. By residual juice we mean the juice remaining in the fiber after the expression of juice by a milling unit, and we apply this term generally to any or all mills.

Table 8 gives a summary of tests on mill and residual juices of the last mill. In some tests water was added to the bagasse before pressing in the laboratory, so that the relation of the Brix has no significance. Brix was by pycnometer.

TABLE 8.

Juices	Tests			Apparent Purity
	Averaged	Brix	Pol'n.	
Last Mill	20	1.58	1.09	68.99
Residual	20	1.70	1.24	72.94

Last Mill juices were collected from the discharge roll.

Residual juices are quite generally higher in purity than the last roll juices.

In Table 9, we give data on residual and last mill juices, showing the relation of solids extracted, no water being added to the bagasse before expression in the laboratory press.

TABLE 9.

Juices	Tests			Apparent Purity
	Averaged	Brix	Pol'n.	
Last Mill	5	1.31	0.92	70.18
Residual	5	3.41	2.54	74.44

The brix of residual juice is thus seen to be considerably higher than that of last roll juice. This is not due to adsorption and is probably due to inefficient incorporation of maceration water.

In Table 10, we show colloid relations. In this series, we added to the bagasse in question its own weight of water, thoroughly mixing by hand before extracting the juice in the laboratory hand press.

TABLE 10.

Juices	Tests Averaged	Brix	Pol'n.	Apparent Purity	Colloids % Brix	App. Pur. Plus Colloids
						% Brix
6 Mill	10	1.77	1.20	67.97	10.22	78.19
6 Residual	10	1.19	0.85	71.48	6.95	78.43
5 Mill	11	3.67	2.60	70.88	6.09	76.97
5 Residual	11	1.76	1.28	72.65	4.72	77.37

These figures show still further that the action of the mills on the fiber produces colloids and that colloids (and probably ash) are directly responsible for the higher purity of residual over last roll juices. It is unfortunate that we cannot show ash relations for these juices.

SUMMARY

Cane tests show an average difference in apparent purity between pith and rind juices of 5.07 points.

The drop in apparent purity from crusher to last mill juice was 7.86 for dry crushing and 20.12 for maceration milling tests.

The low purities of last mill juices cannot be satisfactorily accounted for by the purity of rind juices.

Impurities apparently optically active are introduced into the juice of the last mills. Since approximately 75 per cent of cane fiber is due to the rind, these substances are presumably introduced from the rind.

The ash of mill juices increases steadily from mill to mill, reaching a maximum at the last mill.

The colloids of mill juices increase steadily from mill to mill, reaching a maximum at the last mill.

The characteristics of the last mill are not intrinsic since the corresponding juices of dry crushing tests are not comparable.

Colloidal matter may be prepared from cane fiber in the laboratory.

Juices of dry crushing and maceration milling tests are comparable if colloids and ash are considered.

The higher purities of residual over last roll juices can be accounted for fairly satisfactorily by colloidal matter and perhaps more closely if ash be taken into consideration.

Low purities of last mill juices exist as a direct result of the milling process on cane fiber.

Annual Synopsis of Mill Data, 1923

By W. R. McALLEN.

This synopsis includes operating data from all factories in the Association except one. These data represent 99.6% of the 1923 production. Figures in previous synopses have been for operations from the beginning of the grinding season to September 30. This synopsis is for the year from September 30, 1922, to September 30, 1923, and includes unfinished portions of the 1922 crop of eight factories still grinding on September 30, 1922. Three factories had not finished grinding on the corresponding date this year. Data including portions of the 1922 crop and incomplete 1923 data are so indicated in the first of the large tables.

The form of the three large tables is unchanged. The first contains operating data and averages for the last 10 years, the second, mill settings, roller speed, pressures, etc., and the third, surface and juice grooving. The factories are again listed in the order of the average size of the crop for the preceding five seasons.

It has been customary to compare the work with that of previous seasons on the basis of the averages at the bottom of the first of the large tables. Comparisons on this basis have been rendered difficult and unsatisfactory this year by data from two factories operating the Petree process. These factories produced 12% of the crop. Many of these comparisons have been based on mixed juice figures, and the substitution of clarified juice for mixed juice, necessary in tabulating data from these factories has disturbed the mixed juice averages to the extent that they cannot be so used. The press cake averages are also disturbed to the extent that erroneous conclusions would result from comparisons taking these figures at their face value. Data for factories operating this process should be compiled in a separate table. This hardly seems desirable for two factories only, particularly, as the difficulty in securing comparable averages would not be overcome. Table No. 3 containing true averages for 1922 and 1923 for all factories except these two has been compiled. This permits accurate comparisons with 1922 for the factories using the customary process, but does not entirely obviate the difficulty in making comparisons with the work of preceding years. However, by taking into consideration differences between the 1922 averages in this table and corresponding 1922 averages at the foot of the large table, the comparisons, while not as accurate as is desirable, are fairly satisfactory. Comparisons of the figures in Table 3 with corresponding averages for years previous to 1922 are on this basis.

Before leaving this subject it seems desirable to discuss briefly one or two features of the chemical control in cane sugar factories with particular reference to the Petree process. In the absence of a practicable method for determining the sugar in the cane directly, the amount of sugar entering the factory is usually

TABLE NO. 1
VARIETIES OF CANE.

	Yellow Caledonia	H 109	D 1135	Lahaina	Striped Mexican	Striped Tip & Yellow Tip	Rose Bamboo	D 117	Other Varieties
H. C. & S. Co.....	..	80	4	13	3	..	..	..	..
Oahu.....	4	65	14	15	..	..	..	..	2
Ewa.....	1	93	..	4	..	..	..	..	2
Waiialua.....	16	14	17	17	..	..	4	3	29
Pioneer.....	..	33	12	17	38	..	..	..	..
Maui Agr.....	3	62	6	18	..	..	9	..	2
Olaa.....	88	..	10	..	..	..	..	..	2
Haw. Sug.....	2	24	42	8	..	..	..	..	24
Onomea.....	94	..	1	..	..	5	..	..	..
Honolulu.....	50	43	3	4	..	..	..	..	..
Hakalau.....	98	..	..	..	..	2	..	..	..
Kekaha.....	2	5	22	69	..	..	..	..	2
Lihue.....	87	11	2	..	..	..	..	..	..
Haw. Agr.....	41	..	9	..	1	..	3	..	46*
Hilo.....	98	..	1	..	..	1	..	..	..
McBryde.....	31	46	23	..	..	..	..	..	..
Wailuku.....	1	46	..	20	28	..	..	..	5
Makee.....	83	15	..	..	..	..	..	..	2
Laupahoehoe.....	57	..	5	..	..	35	..	3	..
Honokaa.....	8	11	78	..	..	3	..	..	..
Pepeekeo.....	98	..	1	..	..	1	..	..	..
Kahuku.....	55	35	..	10	..	..	..	..	..
Hamakua.....	48	1	27	..	..	3	..	21	..
Honomu.....	95	1	..	..	..	..	..	4	..
Koloa.....	95	..	5	..	..	..	..	..	..
Paaubau.....	35	7	55	..	..	2	..	..	1
Waiakea.....	100	..	..	..	..	..	..	..	..
Hutchinson.....	31	..	1	..	..	1	67	..	..
Hawi.....	4	27	16	..	1	52	..	..	..
Waianae.....	1	75	..	23	..	..	..	..	1
Kaiwiki.....	44	..	3	..	..	17	1	35	..
Kohala.....	22	..	35	..	..	41	..	..	2
Kilauea.....	77	15	..	..	..	..	..	..	8
Kaeleku.....	100	..	..	..	..	..	..	..	..
Waimanalo.....	88	12	..	..	..	..	..	..	..
Halawa.....	35	..	5	..	..	60	..	..	..
Niulii.....	46	..	10	..	..	44	..	..	..
Waimea.....	..	41	7	49	..	..	..	..	3
Union Mill.....	12	..	13	..	..	75	..	..	..
Oloualu.....	..	34	..	40	26	..	..	..	..
True Average 1923..	36.3	30.7	11.2	8.4	3.1	2.8	1.5	1.0	5.0
“ “ 1922..	40.3	21.1	12.2	12.0	2.8	4.3	1.6	1.2	4.5
“ “ 1921..	45.1	15.0	11.0	17.4	3.0	3.0	1.0	1.1	3.4
“ “ 1920..	42.7	9.1	10.0	26.7	2.5	3.5	0.8	1.0	3.7
“ “ 1919..	46.4	6.8	7.2	29.1	1.8	2.9	2.1	1.1	2.6
“ “ 1918..	42.9	4.0	7.5	37.9	0.6	2.0	1.1	0.8	3.2

* White and Yellow Bamboo 12%.

TABLE NO. 2.
COMPOSITION OF CANE BY ISLANDS.

	Hawaii	Maui	Oahu	Kauai	Whole Group
1914					
Polarization.....	12.75	15.16	14.23	13.62	13.78
Percent Fiber.....	13.62	11.59	12.44	12.75	12.74
Purity 1st Expressed Juice.	88.22	91.02	88.11	87.51	88.71
1915					
Polarization.....	12.61	15.23	14.29	14.09	13.77
Percent Fiber.....	13.00	11.44	12.77	12.46	12.51
Purity 1st Expressed Juice.	87.86	90.48	87.27	86.99	88.24
1916					
Polarization.....	12.54	14.62	13.74	13.26	13.45
Percent Fiber.....	13.22	12.22	12.51	12.86	12.74
Purity 1st Expressed Juice.	87.56	89.41	87.15	86.26	87.70
1917					
Polarization.....	13.31	15.43	13.55	13.13	13.76
Percent Fiber.....	13.23	11.67	12.25	12.89	12.62
Purity 1st Expressed Juice.	88.11	90.69	86.86	86.70	88.02
1918					
Polarization.....	11.88	14.25	13.50	12.54	12.97
Percent Fiber.....	13.35	11.53	12.23	12.84	12.50
Purity 1st Expressed Juice.	87.27	88.62	86.93	85.88	87.18
1919					
Polarization.....	12.74	15.12	14.24	13.52	13.74
Percent Fiber.....	13.07	11.74	12.14	12.61	12.49
Purity 1st Expressed Juice.	87.54	88.81	87.00	85.82	87.34
1920					
Polarization.....	12.86	15.29	13.75	13.07	13.64
Percent Fiber.....	13.36	11.39	12.65	12.72	12.64
Purity 1st Expressed Juice.	87.87	88.94	85.40	86.52	87.24
1921					
Polarization.....	12.25	14.67	13.72	12.67	13.12
Percent Fiber.....	13.28	11.82	12.40	13.28	12.80
Purity 1st Expressed Juice.	87.18	87.37	85.46	84.07	86.22
1922					
Polarization.....	12.07	13.95	13.61	13.03	12.97
Percent Fiber.....	13.16	12.38	12.88	13.22	12.95
Purity 1st Expressed Juice.	87.17	87.88	86.18	85.80	86.84
1923					
Polarization.....	12.09	13.61	12.99	12.94	12.78
Percent Fiber.....	13.14	12.01	12.86	12.99	12.82
Purity 1st Expressed Juice.	87.61	88.65	85.52	86.58	87.05

calculated from the weight and analysis of the mixed juice and the weight and polarization of the bagasse. Undetermined losses in the mill do not appear as losses, but instead reduce the amount of sugar that should be credited to the cane. This method then fails to give the correct figure for sugar entering the factory by the amount of undetermined loss in the mill. All undetermined losses in the boiling house, however, contribute to the undetermined loss shown by the control on this basis. In the Petree process mixed juice figures are not available and the weight and analysis of the clarified juice must be substituted for the mixed juice, in calculating the sugar entering the factory. With the control on this basis not only undetermined losses in the mill, but also undetermined losses up to the point where the clarification is complete, reduce the amount of sugar credited to the cane instead of appearing as losses. Undetermined losses shown by the control on this basis are those occurring subsequent to clarification, that is, in boiling operations. Hawaiian data so far available, for returning settlings to the mill and basing the control on clarified juice indicate that the sugar credited to the cane is less than would be credited operating in the customary manner and basing the control on mixed juice. If the amount of sugar on which the control is based is thus reduced, recovery figures will be too high in comparison with corresponding figures for the usual process. A part, though not all, of the difference in the amount of sugar credited to the cane, is due to a loss in the mill with the Petree process which escapes our methods of control. The amount of bagasse is increased by an amount in proportion to the solids that would otherwise be in the press cake. With both processes, however, the calculated amount of bagasse is the same. The result is that in the Petree process a loss that would otherwise occur in press cake is transferred from the filter presses to the mill where it does not appear as a loss, but instead reduces the amount of sugar that otherwise would be credited to the cane. This varies with the quality of the milling work. With good milling work it may be reduced to the equivalent of the loss in press cake at 0.75% polarization, while with poorer milling work it may become the equivalent of loss in press cake at 2.0% polarization.

On casual examination differences due to changing the basis of the control from mixed juice to clarified juice with settlings returned to the mill may appear negligible. On critical examination of available data, however, differences due to thus changing the basis of the control appear much greater and erroneous conclusions from direct comparison of corresponding figures are probable.

VARIETIES OF CANE

Table 1 shows the proportion of the principle varieties of cane ground at each factory. Averages at the bottom of the table show the proportion of each of these varieties to the entire crop for the past 6 years.

The most noticeable feature is the large increase in the percentage of H 109. In 1922, the proportion of Yellow Caledonia was almost twice that of H 109. This season Yellow Caledonia has decreased to 36.3% while H 109 has increased to 30.7%, leaving Caledonia in first place by a comparatively narrow margin. The

TABLE NO. 3.

True averages of all factories except those now using the Petree process.

	1922	1923
Cane—		
Polarization	12.78	12.65
Fiber	13.04	12.93
Tons per ton sugar.....	8.78	8.69
Bagasse—		
Polarization	1.73	1.52
Moisture	41.38	41.31
Fiber	56.14	56.48
Polarization % Cane	0.40	0.35
Polarization % pol. of cane.....	3.14	2.76
Milling Loss	3.08	2.71
Weight % cane.....	23.22	22.89
First Expressed Juice—		
Brix	18.23	17.99
Polarization	15.79	15.62
Purity	86.63	86.81
"Java ratio"	80.9	81.0
Mixed Juice—		
Brix	13.26	13.12
Polarization	11.08	11.00
Purity	83.51	83.88
Weight % cane	111.56	111.85
Polarization % cane	12.38	12.31
Extraction	96.86	97.24
Extraction ratio	0.24	0.21
Last Expressed Juice—		
Polarization	1.98	1.74
Purity	69.49	68.55
Maceration % cane.....	34.96	34.73
Syrup—		
Brix	63.02	63.24
Purity	84.80	85.41
Increase in purity.....	1.29	1.53
Press Cake—		
Polarization	2.07	2.29
Weight % cane.....	2.51	2.46
Polarization % cane	0.05	0.06
Polarization % pol. of cane.....	0.41	0.45
Lime used % cane.....	0.081	0.086
Commercial Sugar—		
Polarization	96.88	96.87
Moisture	0.86	0.80
Weight % cane	11.39	11.51
Polarization % cane	11.04	11.15
Polarization % pol. of cane.....	86.80	88.33
Polarization % pol. of juice.....	89.57	90.81
Final Molasses—		
Weight % cane	3.10	2.95
Sucrose % cane	1.05	0.99
Sucrose % pol. of cane.....	8.25	7.78
Sucrose % pol. of juice.....	8.51	8.00
Gravity solids	87.93	88.54
Gravity purity	38.64	37.76
Undetermined Losses—		
Polarization % cane	0.23	0.11
Polarization % pol. of cane.....	1.40	0.68

percentage of Striped Mexican has increased slightly. The proportion of all the principal varieties, except H 109 and Striped Mexican, has decreased. The relatively large decrease in Lahaina has left D 1135 in third place by a comfortable margin.

Minor varieties included in the column "Other Varieties", making up 1% or more of the crop at any factory are:

Variety	% of Total Crop
H 146	0.79
Yellow Bamboo	0.35
H 20	0.15
Badila	0.13
White Bamboo	0.12
H 227	0.12
<hr/>	
Total.....	1.66

QUALITY OF CANE

The composition of the cane by Islands and for the whole group for the past 10 years appears in Table 2. The purity of the first expressed juice is better than in 1922, except on the island of Oahu. For the whole group, it is better than in the two preceding seasons. The polarization of the cane on Hawaii is slightly better than last year. On all other islands it is lower, bringing the average some 0.2 below that of the last year. The fiber is slightly lower than in 1922 on all islands. Compared with the previous season the quality of the cane is slightly better on Hawaii, on Kauai slightly poorer, and on Maui somewhat poorer. On Oahu it is much poorer, amounting to an increase of 0.43 in quality ratio. The average quality of the cane is poorer than in any previous year for which we have a record. Compared with 1922 the increase in quality ratio amounts to 0.12. Almost without exception the cane has been poorer in quality from season to season. In the last ten years there have been but two seasons when this was not the case.

MILLING

Milling data indicate a satisfactory improvement over the work of the previous season. Twenty-nine factories report lower bagasse polarization and twenty-two lower moisture in bagasse. Twenty-eight factories report higher extraction against eleven lower, and twenty-seven better milling loss against twelve poorer. Twenty-one factories report less maceration against eighteen more.

Comparing the averages for all factories with 1922, we find the average polarization in bagasse reduced from 1.69 to 1.55, but the average moisture has increased from 41.51 to 41.56. Maceration has increased from 34.75 to 35.12% cane. The milling loss has been reduced from 3.02 to 2.76, an improvement of 0.26. Extraction figures show an improvement from 96.98 to 97.23. Extraction data from Petree process factories, as previously noted, are not directly compara-

ble with data from other factories and on this account the above average is not on a strictly comparable basis with averages for previous years. One Petree process factory reports better and one poorer milling work than last year. Both report poorer work than in preceding seasons. Comparisons of the averages for factories exclusive of these two, appearing in Table 3, indicate greater improvement in milling work than is shown by the figures just noted. Bagasse polarization has been reduced from 1.73 to 1.52, an improvement of 0.21. Moisture in bagasse instead of showing an increase has been reduced from 41.38 to 41.31. Maceration has also been reduced from 34.96 to 34.73. The latter figure is lower than in any year since 1914. The milling loss has been reduced from 3.08 to 2.71, a difference of 0.37, the extraction has been increased from 96.86 to 97.24, an improvement of 0.38, and the extraction ratio has been reduced from 0.24 to 0.21. On the basis of the milling loss these factories report a quality of work very nearly the equivalent of 1921, but better than in any other year. The extraction itself, however, is lower than in 1920 and 1921.

Hydraulic pressure has been increased. In 1922 the average was 65.19 and in 1923, 66.15 tons per linear foot of roller, an increase of approximately one ton. Fifteen factories report heavier pressure, sixteen the same and eight factories lower pressure.

Subsequent to the publication of the synopsis last year, it was suggested that the relatively poor milling results in 1922 might be due to an increase in the grinding rate. To study this factor average grinding rates have been calculated by dividing the total tons of cane by the total hours grinding. These figures follows:

1920.....	39.34
1921.....	36.58
1922.....	39.93
1923.....	42.03

The grinding rate in 1922 was indeed 9% higher than in the previous year. It was, however, but slightly higher than in 1920 when the extraction was high. There is a further increase of 6% in the 1923 grinding rate. Extraction, however, has improved to almost the 1920 and 1921 standard. Losses in extraction, difficult to avoid, have resulted in individual cases from large increases in the grinding rate. 1923 data, however, indicate that neither the reduced maceration nor the higher grinding rate was necessarily responsible for poor milling work in 1922. It is more probable that the major factor was decreased interest in securing high extraction.

This season there has been a further reduction amounting to 0.19 in the difference in purity between first expressed and mixed juice. Gravity purity of mixed juice has been reported in 1923 Oahu Sugar Company data, while first expressed juice is still on apparent purity basis. The change has affected the averages to the extent of 0.01 and to be on a strictly comparable basis the above figure should be 0.18 instead of 0.19. While Maui Agricultural Company reports on the same basis comparisons with previous years are not affected as this has

been the practice for a number of years. The difference between first expressed and mixed juice purity is the only figure on which inference as to the deterioration in the milling process can be based. Unfortunately several factors affect it to a greater or less extent. The relative purity of the first expressed juice varies according to the proportion of the total juice the sample represents. It may also vary somewhat with different varieties of cane. While direct comparison between individual factories is thus rendered difficult, at the same factories from period to period, particularly when grinding the same variety of cane, and in the averages for all factories from one year to another the relative purity of the first expressed juice is probably sufficiently constant for changes in the purity difference between first expressed and mixed juice to be ascribed to relative changes in mixed juice purity. As a difference of one point in the purity of a juice may be considered fairly close to the equivalent of a difference of one point in the recovery that can be obtained from it, changes in the relative purity of the mixed juice are most significant. Factors affecting the relative purity of the mixed juice are extraction, possibly the amount of maceration, trash on the cane and deterioration in the mill. In 1922 the difference between first expressed and mixed juice purities was 0.34% lower than in the previous year. In that year there was a considerable reduction both in extraction and in maceration. From an analysis of available data presented in the last synopsis, the conclusion was drawn that no considerable part of the reduction in this difference was due to lower extraction or reduction in maceration. Further improvement this year, notwithstanding a material increase in extraction and but little change in maceration, adds weight to this conclusion. The difference this season is smaller than in any of the ten years for which data are available, though in 1914 the extraction was almost two points lower than at present.

Extraction of impurities from field trash and deterioration in the mill are probably the most important factors affecting the relative purity of the mixed juice and thus causing changes in this difference in purity. No figures for the amount of field trash are available, so we can draw no conclusions as to how much this factor has influenced averages from year to year. We do know, however, that well planned efforts to improve mill sanitation have almost invariably resulted in a decrease in the difference between first expressed and mixed juice purities, and that at most of the factories, efforts in this direction have been made in the last two years. The purity difference is now 0.53 smaller than in 1921. In the absence of figures for field trash we do not, of course, know whether all of it or a part only can be ascribed to improvements in mill sanitation. The value of the corresponding increase in recovery, however, would appear ample to repay efforts that may have been made both in reducing field trash and reducing destruction of sugar in the mill. Further improvement is no doubt possible, particularly if satisfactory substitutes are developed for the present mill screens, in which more or less deterioration takes place. The above comments, in so far as they refer to 1923, are based on the averages in Table 3, for the substitution of clarified for mixed juice purities in data from the Petree process factories has

TABLE NO. 4—MILLING RESULTS.

Showing the Rank of the Factories on the Basis of Milling Loss.

Factory	Milling Loss	Extraction Ratio	Extraction	Equipment
1. Onomea.....	1.09	0.09	98.88	2RC60,854,12RM66
2. Hakalau.....	1.09	0.09	98.87	2RC54,12RM9-60,3-66
3. Hilo.....	1.22	0.10	98.60	K,2RC60,12RM66
4. Pepeekeo.....	1.92	0.15	98.02	2RC54,9RM60
5. Olowalu.....	1.98	0.15	98.24	K,3RC48,9RM48
6. Hamakua.....	2.07	0.17	97.62	K,2RC60,12RM60
7. Lihue.....	2.20	0.18	97.69	K,2RC78,S72,12RM78
8. Makee.....	2.25	0.19	97.36	K,2RC72,S72,9RM72
9. Paauhau.....	2.31	0.20	97.28	2RC60,12RM66
10. Oahu.....	2.38	0.17	97.85	K(2),2RC78(2),S72(2),12RM78(2)
11. Pioneer.....	2.45	0.18	97.90	K,2RC72,S72,15RM72
12. Kilauea.....	2.47	0.22	97.11	K,S,3RC60,9RM60.
13. Wailuku.....	2.55	0.20	97.55	K,2RC72,12RM78
14. Haw. Agr.....	2.59	0.22	97.07	3RC60,12RM66
15. Waimea.....	2.60	0.21	97.57	2RC48,12RM42
16. Haw. Sug.....	2.63	0.18	97.73	K,2RC72,S72,12RM78
17. Honomu.....	2.67	0.22	97.35	2RC60,9RM60
18. Ewa.....	2.77	0.22	97.10	K(2),2RC78,18RM78
19. Maui Agr.....	2.78	0.21	97.56	K(2),3RRC66,18RM66
20. Koloa.....	2.78	0.23	96.86	K,2RC60,12RM66
21. Waialua.....	2.82	0.22	97.25	K(2),2RC78,12RM78
22. Kahuku.....	2.88	0.25	96.09	3RC60,854,9RM72
23. Hutchinson.....	2.95	0.27	96.50	2RC60,9RM60
24. Laupahoehoe.....	2.97	0.24	96.95	K,2RC60,9RM60
25. McBryde.....	3.24	0.25	96.48	2RC72,S72,9RM84
26. Olaa.....	3.25	0.26	96.60	K,S72,12RM78
27. Waianae.....	3.41	0.26	96.68	K(2),12RM60
28. Honokaa.....	3.42	0.30	96.16	K(2),2RC66,12RM66
29. Kaiwiki.....	3.52	0.29	96.19	K,2RC60,9RM60
30. H. C. & S. Co.....	3.54	0.25	96.98	K(4),2RC78(2),S72(2),12RM78(2)
31. Waiakea.....	3.68	0.29	96.00	K,S42,2RC60,9RM60
32. Kohala.....	3.71	0.31	95.95	K(2),3RC60,9RM60
33. Honolulu.....	3.76	0.28	96.59	K(2),S54,2RC78,9RM78
34. Kekaha.....	4.10	0.30	96.42	2RC54,9RM60
35. Kaeleku.....	4.24	0.36	94.86	K,2RC54,9RM60
36. Hawi.....	4.76	0.35	95.77	K(2),2RC54,12RM54
37. Union Mill.....	5.41	0.47	93.16	K,9RM60
38. Halawa.....	5.81	0.50	92.86	K,2RC60,6RM50
39. Niulii.....	6.43	0.56	91.79	K,9RM54

affected the average mixed juice purity in the large table to the extent that it cannot be used in these comparisons.

Though no factory has this year reported 99 extraction, two factories, Onomea and Hakalau have made new records in milling loss, both reporting 1.09. The previous record, 1.10, was made by Hakalau in 1922. Onomea has made a new record in bagasse polarization, reporting 0.66 against the previous low point, 0.67, reached by Hakalau last year.

Comparisons of Table No. 4 in which the factories are ranked in the order of the size of milling loss, with the corresponding table in the last year's synopsis, shows many changes in relative rank. Hamakua has made the largest change, advancing from thirty-sixth to sixth place. Oahu has advanced from twenty-sixth to tenth, Ewa from thirtieth to eighteenth, and Olowalu from fifteenth to fifth. Other factories that have materially improved their standing are Kahuku, Kaiwiki, Kilauea, Maui Agricultural Company, Waianae, Waiakea and Lihue. H. C. & S. Co. has dropped from fifth to thirtieth place, Koloa from ninth to twentieth, and Hawi from twenty-fourth to thirty-sixth. Honokaa, Kaeleku, Laupahoe, Wailuku, Kekaha, Hawaiian Sugar, McBryde, Olaa, Paauhau and Honomu have all dropped several points in relative standing, though four of these, Laupahoe, McBryde, Oahu and Paauhau report improved work.

EXTRA FUEL

Fifteen factories have reported extra fuel in more than small amounts, such as may be required for starting up, or be occasioned by unexpected delays. Eight of the fifteen report smaller amounts of extra fuel than in 1922.

Last season attention was called to the fact that theoretically the bagasse, particularly when supplemented with molasses, should furnish sufficient fuel to maintain a high quality of work and that with proper operation and with equipment suitable for the conditions under which a factory operates this holds true in practice. The writer includes in the term "proper operation" a sufficient supply of cane to grind at a reasonable capacity.

Data reported this season confirm this conclusion. In addition to Pioneer, Ewa may be cited as a factory where no extra fuel is now required though formerly large quantities were burned. Though no extra fuel was burned at this factory in 1922, it was not then cited as an example, for in that year a part of the milling machinery was not available during a considerable portion of the season, preventing a fair comparison. This year with all the milling machinery in operation, fuel requirements have been met, without the use of extra fuel. Two only of the eleven factories ranking highest in milling work have reported any extra fuel. One is handicapped by an inadequate supply of cane. At the other extra fuel consumption has been reduced to between 20 and 25% of the 1922 requirement. It is planned to greatly reduce or eliminate the present requirement by correcting known defects that could not well be attended to during the grinding season. The greater number of factories using extra fuel are among those reporting comparatively poor milling work. Of the first twenty

TABLE NO. 5.
GRAVITY SOLIDS AND SUCROSE BALANCES.

Factory	GRAVITY SOLIDS PER 100 GRAVITY SOLIDS IN MIXED JUICE				SUCROSE PER 100 SUCROSE IN MIXED JUICE			
	Press Cake	Commercial Sugar	Final Molasses	Undeter- mined	Press Cake	Commercial Sugar	Final Molasses	Undeter- mined
H. C. & S. Co.....	0.6	84.9	13.7	0.8	0.1	93.5	6.0	0.4
Oahu.....	2.9	79.4	16.1	1.6	0.3	92.0	7.3	0.4
Ewa.....	5.6	73.0	18.6	2.8	0.3	90.0	8.3	1.4
Waialua.....	5.4	73.9	18.1	2.6	0.6	89.2	8.9	1.3
Pioneer.....	3.5	78.9	15.8	1.8	0.3	92.3	6.8	0.6
Maui Agr.....	...	83.9	14.1	2.0	...	94.9	6.5	-1.4
Onomea.....	5.0	78.7	14.7	1.6	0.1	92.4	6.3	1.2
Hakalau.....	3.8	79.0	14.5	2.7	0.1	92.4	6.2	1.3
Haw. Agr.....	4.2	77.3	17.1	1.4	0.8	88.3	7.8	3.1
Hilo.....	5.2	77.6	15.0	2.2	0.3	92.4	6.9	0.4
McBryde.....	4.4	75.4	21.0	-0.8	0.3	89.3	9.4	1.0
Wailuku.....	4.8	78.3	16.1	0.8	0.2	91.9	7.4	0.5
Makee.....	2.7	73.4	18.5	5.4	0.3	87.9	8.5	3.3
Lanpahoehoe.....	4.3	77.4	18.1	0.2	0.2	90.2	8.5	1.1
Honokaa.....	5.7	74.6	18.6	1.1	0.4	89.9	9.0	0.7
Pepeekeo.....	3.2	79.4	14.0	3.4	0.1	92.7	5.8	1.4
Hamakua.....	8.6	72.2	14.1	5.1	1.7	87.9	7.5	2.9
Honomu.....	5.0	78.0	15.1	1.9	0.4	92.2	6.5	0.9
Paaupau.....	6.5	75.5	17.3	0.7	0.5	90.8	7.8	0.9
Waiakea.....	5.2	76.0	14.0	4.8	0.5	89.6	6.7	3.2
Hutchinson.....	5.1	74.3	17.9	2.7	0.3	88.2	8.8	2.7
Kilauea.....	3.0	69.9	17.6	9.5	0.9	85.5	8.7	4.9
Union Mill.....	10.2	70.6	17.9	1.3	1.5	87.8	9.6	1.1

factories in Table 4, less than a third reported extra fuel, against almost a half of the nineteen factories in the lower half of the table.

It would seem desirable in factories requiring extra fuel to make a survey of operating methods and equipment to determine what factors are responsible. In some cases comparatively minor changes in methods and equipment will result in marked improvement. In others faulty design renders satisfactory solution of the problem more difficult. The writer believes that, save in exceptional cases, it will be found more economical to correct faulty conditions than to continue expenditures for extra fuel, particularly as the quality of the work is usually poorer during periods of fuel shortage.

Both factories operating the Petree process report extra fuel. A large reduction over previous requirements was made at one factory. At the other the amount is much larger than last year, but in somewhat near the same proportion as in preceding seasons.

SUCROSE BALANCES AND CHEMICAL CONTROL

Gravity solids and sucrose balances for factories reporting sucrose data are in Table 5. Two additional factories have reported sucrose data this year making a total of 23 factories with the control on a sucrose basis.

Table 6 is a comparison of recoveries with the calculated available based on polarization figures. Table 7 is a similar calculation for the factories reporting the necessary data on the more reliable true sucrose basis. It should be noted that 100% in these tables is not necessarily the maximum possible recovery, but rather the amount of sugar that a calculation indicates should be recovered with the reported syrup, sugar and molasses purities. Figures for "recovery on available" are then principally checks on the accuracy of the chemical control, though low figures may be due to losses.

Defects in control based on polarization have been commented on in previous synopses. Data in these tables further emphasize the inadequacy of control on this basis. The figure for undetermined loss is deceptively low. The arithmetical average for the undetermined losses on a sucrose basis for the factories listed in Table 5 is 0.7 higher than is shown by polarization figures. Comparisons of other data in Table 5 with corresponding polarization figures, and comparisons of corresponding figures in Tables 6 and 7 disclose further discrepancies in figures based on polarization. Chemical control based on polarization has served a valuable purpose in making apparent the comparatively large avoidable losses that were formerly common in factory operation. As a result such losses have been reduced through more efficient factory operation. With the present standard of factory work greater refinement in the control is essential and the discrepancies inherent in a control based on polarization should be eliminated. Formerly a sucrose control was hardly practicable, particularly at the smaller factories, for the determinations were time consuming and required a high degree of skill. Methods have now been simplified to the extent that it is practicable to have the determinations made by good laboratory assistants and it has been estimated by

TABLE NO. 6.
APPARENT BOILING-HOUSE RECOVERY.

Comparing percent available sucrose in the syrup (calculated by formula) with percent polarization actually obtained.

Factory	Available *	Obtained	Recovery on Available
H. C. & S. Co.....	92.77	94.80	102.2
Oahu.....	91.76	92.25†	100.5
Ewa.....	90.42	91.47	101.2
Waiialua.....	90.10	90.27	100.2
Pioneer.....	92.42	92.78	100.4
Maui Agr.....	91.39	94.88 †	103.8
Olaa.....	91.02	91.16	100.2
Haw. Sug.....	92.72	93.15	100.5
Onomea.....	93.33	92.80	99.4
Hakalau.....	92.73	93.26	100.6
Kekaha.....	92.89	90.66	97.6
Lihue.....	90.87	92.01	101.3
Haw. Agr.....	92.73	89.75	96.8
Hilo.....	91.95	92.84	101.0
McBryde.....	91.83	90.31	98.3
Wailuku.....	92.44	92.43	100.0
Makee.....	89.46	89.00	99.5
Laupahoehoe.....	92.11	90.59	98.3
Honokaa.....	90.74	90.51	99.7
Pepeekeo.....	92.97	93.13	100.2
Kahuku.....	89.63	90.09	100.5
Hamakua.....	90.17	89.81	99.6
Honomu.....	93.02	93.00	100.0
Koloa.....	87.56	87.93	100.4
Paaauhau.....	92.42	91.28	98.8
Waiakea.....	91.62	90.65	98.9
Hutchinson.....	90.51	89.26	98.6
Hawi.....	91.01	85.82	94.3
Waianae.....	88.58	88.46	99.9
Kaiwiki.....	90.45	90.68	100.3
Kohala.....	91.09	91.32	100.3
Kilauea.....	87.33	87.98	100.7
Kaeleku.....	88.29	87.48	99.1
Halawa.....	88.95	85.76	96.4
Niulii.....	89.99	89.42	99.4
Waimea.....	90.06	91.26	101.3
Union Mill.....	89.67	90.01	100.4
Olowalu.....	88.88	82.99	93.4

* In order to calculate the available sucrose it is necessary to estimate the gravity purity of the syrup and sugar. Data from factories determining both apparent and gravity purities indicate that the average correction necessary is the addition of 0.8 to the apparent purity of the syrup and 0.8 to the apparent purity of the sugar. When the moisture in the sugar has not been reported 1% has been taken. 88 has been used when the gravity purity of the molasses has not been reported.

† Sucrose.

TABLE NO. 7.
TRUE BOILING-HOUSE RECOVERY.
 Comparing percent sucrose available and recovered.

Factory	Available	Obtained	% Recovery on Available
H. C. & S. Co.....	93.16	93.59	100.5
Oahu.....	91.76	92.28	100.6
Ewa.....	90.53	90.27	99.7
Waialua.....	89.81	89.74	99.9
Pioneer.....	92.35	92.58	100.2
Maui Agr.....	91.39	94.90	103.8
Onomea.....	93.29	92.49	99.1
Hakalau.....	92.78	92.49	99.7
Haw. Agr.....	93.14	89.01	95.6
Hilo.....	91.71	92.68	101.1
McBryde.....	91.74	89.57	97.6
Wailuku.....	92.29	92.08	99.8
Makee.....	89.54	88.16	98.5
Laupahoe.....	92.07	90.38	98.2
Honokaa.....	90.58	90.26	99.6
Pepeekeo.....	92.83	92.79	100.0
Hamakua.....	89.72	89.42	99.7
Honomu.....	92.67	92.57	99.9
Paauhau.....	92.26	91.30	99.0
Waiakea.....	91.60	90.05	98.3
Hutchinson.....	90.75	88.47	97.5
Kilauea.....	86.65	86.28	99.6
Union Mill.....	89.80	89.14	99.3

TABLE NO. 8.
PERCENT MOLASSES PRODUCED ON THEORETICAL.

H. C. & S. Co.....	90.7	Laupahoe.....	97.2
Oahu.....	90.9	Honokaa.....	93.5
Ewa.....	88.8	Pepeekeo.....	81.4
Waialua.....	88.7	Kahuku.....	83.5
Pioneer.....	89.3	Hamakua.....	74.6
Maui Agri.....	87.3	Honomu.....	92.2
Olaa.....	92.9	Koloa.....	81.8
Haw. Sug.	90.3	Paauhau.....	96.6
Onomea.....	89.2	Waiakea.....	75.0
Hakalau.....	84.6	Hutchinson.....	86.8
Kekaha.....	92.5	Hawi.....	97.9
Lihue.....	87.7	Kaiwiki.....	86.3
Haw. Agr.	91.0	Kohala.....	92.9
Hilo.....	86.6	Kilauea.....	71.0
McBryde.....	105.8	Kaeleku.....	89.9
Wailuku.....	96.7	Union Mill.....	93.6
Makee.....	78.0	Olowalu.....	91.5

factory chemists that the time required for the necessary determinations does not exceed from one-half hour to one hour per day. The control at 60% of the factories is now on a sucrose basis and it would seem most desirable for the remaining factories to make the change.

Molasses data is a feature of the chemical control that is gradually improving in accuracy from year to year. This year but one factory failed to report molasses purity. All but four reported molasses weights. At twenty-two factories producing 70 to 75% of the total quality, the molasses was weighed instead of the weight being calculated from measurements.

Data for molasses produced on theoretical, Table 8, have been more consistent from year to year since this table was first calculated. On the whole, even though one factory reports more than 100%, the figures may be considered somewhat more consistent than last year. The theoretical amount of molasses could be calculated on a much more logical basis than that used at present if a sufficient number of the factories reported sucrose data for all calculations to be made on this basis.

BOILING HOUSE WORK

Clarification: Data for clarification indicate a continuation of the improvement that was noted last year in this phase of the work. Twenty-three factories report larger increases in purity, three report the same and eleven smaller increases. No factories reported decreases in purity from mixed juice to syrup either in 1922 or 1923, though for several seasons prior to these, such decreases had been reported. The tendency to use a larger amount of lime, shown by the figures for the preceding two years, has continued this season. The increase has been from 0.084 to 0.087% on cane. The average increase in purity from mixed juice to syrup (Table 3) is 1.53 against 1.29 in 1922. This is the largest increase in purity since 1918. The syrup purity is higher than in any year since 1919. Somewhat less than one-third of the improvement over last season may be credited to higher initial purities. The remainder is due to better results in clarification and a smaller decrease in purity from first expressed to mixed juice.

Lack of mixed juice analyses has prevented including Petree process factories in the above comparison. They can be included in comparisons of first expressed juice and syrup purities, though such comparisons are affected by factors other than clarification. Twenty-eight factories report smaller, one the same and ten larger differences between first expressed juice and syrup purities. Averages for the past three years are:

1921.....	2.32
1922.....	1.88
1923.....	1.40

The latter figure is lower than in any year for which averages are available, except 1914 and 1918, in both of which years the figure was also 1.40. The im-

provement compared with 1921 is 0.92. Compared with 1922, it is 0.48. Improvements in purity as large as this are the equivalent of material improvements in recovery.

Both Petree process factories reduced this difference between first expressed juice and syrup purities in comparison with the previous year, H. C. & S. Co. to the extent of 0.60, and Maui Agricultural Company to the extent of 1.45. At the latter factory the lime used was increased from 0.075 to 0.10, or 33%.

Filtration: Data for filter press operation show much less satisfactory conditions. While figures at the foot of the large table indicate lower polarization and a smaller quantity of press cake, this is due to data from Petree process factories, accentuated because at these factories the filter press losses in 1922 were over twice as large as the average. Data in Table 3 show an increase in the polarization of the press cake from 2.07 in 1922 to 2.29 in 1923. The quantity has decreased from 2.51 to 2.46% on cane. The decrease in quantity has not been enough to offset the increase in polarization and the loss per cent polarization of cane has increased from 0.41 to 0.45. Present filtration practice is far from satisfactory and improvements are greatly needed.

Evaporation: The brix of the syrup was 63.26 and that of the mixed juice 13.13, indicating 79.24% evaporation; the highest figure yet recorded. The brix of the syrup was 0.11 lower than in 1922, but higher than in any other year for which averages are available.

Commercial Sugar: The commercial sugar has increased slightly in polarization the average being 96.90 against 96.88 last year. This is the highest polarization since 1913.

Averages for moisture in sugar indicate a marked improvement in this phase of the work. The moisture content has been reduced from 0.87 to 0.83. The corresponding deterioration factors are 0.279 and 0.268. Further improvement in this respect is desirable for available data indicate that deterioration is possible in Hawaiian sugars with a deterioration factor exceeding 0.25, while it has not been detected in sugar with a lower deterioration factor. Averages in Table 3 show a much greater improvement in this respect than is shown by averages for all of the factories. The deterioration factor has been reduced from 0.276 in 1922 to 0.256 in 1923. The latter figure is fairly close to what may be considered a safe point.

Low grade work has also greatly improved this year. Twenty-five factories report lower molasses purity against ten reporting higher. Kahuku has established a new record, finishing the season with an average of 33.16 gravity purity. A part of the 1922 crop ground subsequent to September 30, is included in the above. The average for the 1923 crop exclusive of this is still better, 32.92. The previous low average for a season was 33.95 reported from Pepeekeo in 1920.

The average gravity purity, 37.90, is also a new record. It is 0.85 lower than the 1922 average and .05 lower than the previous low point reached in 1919. The quantity of molasses per cent cane, and also the loss per cent polarization in cane and per cent polarization in mixed juice has been materially reduced. The percentage of molasses on cane is smaller than in any year since 1915. The only season since 1916 in which the loss per cent polarization in cane and per cent polarization in mixed juice was smaller than this year is 1919.

Opinions have been expressed that alkaline clarification renders it more difficult to attain low molasses purities. Such opinions are not without foundation, for a high glucose content renders it somewhat easier to attain a given molasses purity, and with acid clarification there will be a greater amount of glucose because of inversion of sucrose during the manufacturing process. We know that if the density is sufficiently high sugar will crystalize from molasses till the gravity purity is below 30 and this information defines the problem of securing low final molasses as the mechanical one of separating the molasses from the crystals. That the gravity purity of the final molasses is lower this year than ever before, though the amount of lime is the largest so far reported, is a strong indication that, while the average molasses purity is considerably above the point to which we know the crystallization of sugar will reduce it, such factors as the one under discussion are of decidedly secondary importance.

RECOVERY

While the quality of the cane has decreased from year to year, in the last two seasons this has been due to a smaller percentage of sugar and not to lower purity. As the purity has increased, from the standpoint of boiling house operations, the quality has improved, and other factors being equal, improved recovery would be expected. The total recovery or recovery per cent polarization in cane is higher than in any previous year while the boiling house recovery or recovery per cent polarization in mixed juice is higher than in any year since 1913. While the 1923 recovery figures are not exactly comparable with previous figures because of data from Petree process factories, the discrepancies are not great enough to affect the accuracy of the above statments.

In the years prior to 1913, in which higher boiling house recoveries were reported, the control was usually based on juice measurements rather than on weights, and as it has usually been found on changing from measuring to weighing that the amount of sugar previously calculated as entering the factory was less than it should have been, there is reason to consider earlier figures high in comparison with later data. While in these years, the juice in the cane was of higher purity than at present and higher boiling house recoveries might reasonably be expected, it is not at all improbable that actually the boiling house recovery this year as well as the total recovery is better than in any previous season.

Compared with 1922 the improvement in boiling house recovery has been much greater than is accounted for by the higher purity in the cane. Data in Table 3, which are on a strictly comparable basis, indicate an improvement of

1.24 in boiling house recovery. Analysis of the figures indicate that 15% of the improvement may be credited to better initial purity and the remainder about equally divided between smaller undetermined loss, lower molasses purity and increase in syrup purity due to better increase in purity in clarification and smaller decrease from first expressed to mixed juice purity.

Figures in the same table indicate an improvement over last year in total recovery of 1.53. This is considerably greater than the 1.24 improvement in boiling house recovery. Higher extraction this season is responsible for the difference.

The improvement in factory work is shown by a comparison of quality ratio with tons of cane actually required to make a ton of sugar. Quality ratios for 1922 and 1923 are 8.45 and 8.57 indicating an increase of 0.12 of a ton in the estimated amount of cane required to make a ton of sugar. Instead of being increased the actual amount required has been reduced from 8.62 to 8.56, a reduction of 0.06 of a ton, that is, there has been a net gain of 0.18 of a ton in the amount of cane required to make a ton of sugar due to better factory work. Incidentally it will be noted that the quality ratio calculation corresponds very closely with present average practice, 8.57 tons being indicated against 8.56 actually required.

The trend of factory work this year has been most satisfactory. Compared with last season higher extraction has been secured, though it is still slightly below that secured in 1920 and 1921. The improvement in extraction has been accompanied by a smaller drop in purity from first expressed to mixed juice. Better results have been secured in clarification and there has been a material decrease in the purity of the final molasses. The increase in recovery is larger than is accounted for by the above factors and higher initial purity, a result principally due to reduction in undetermined losses. Another material improvement is the reduction in moisture in commercial sugar, thus reducing the probability of loss between factory and refinery. The only feature of the work showing an unsatisfactory trend is filter press operation and in this phase of the work operating methods and equipment are greatly in need of improvement.

Experimental work has shown that it is possible to secure the expected recovery from the last increments of extraction and that inversion of sucrose takes place at reactions that were formerly considered safe. Other experiments have pointed the way to better increases in purity during clarification. Critical examination of the figures in synopses for the last few years, furnishes convincing proof that with proper factory operation the expected recovery is actually secured from the last increments of extraction and that the actual gain in recovery of sugar agrees reasonably well with the expected gain from larger increases in purity during clarification and reduction of inversion through carrying juices at the proper reaction.

Figures were presented in the Annual Synopsis for 1921 showing that for two seasons recoveries had been decreasing to a greater extent than could be attributed to changes in the quality of the cane and that this was due to poorer

boiling house work. A criticism of the milling might well have been made also, for in these years the difference between the first expressed and mixed juice purities had been increasing. This year, data can be presented for the past two seasons showing much more satisfactory conditions.

The following figures have been tabulated for convenient reference:

	Extraction	Purities			Total Recovery	Molasses Loss	Undeter- mined Juice
		First Expressed	Mixed Juice	Syrup			
1921....	97.43	86.22	82.77	83.90	85.86	9.27	1.97
1922....	96.98	86.84	83.73	84.96	87.02	8.16	1.27
1923....	97.23	87.05	84.12	85.65	88.77	7.58	.48

As previously noted some of the 1923 figures are not on a comparable basis with those of previous years, and it is necessary to take the probable size of the discrepancies into consideration in making comparisons. It has been necessary to calculate the mixed juice purities from the ratio of mixed juice to first expressed juice and syrup purities in Table 3. The probable accuracy is one or two in the second decimal place. The figure for extraction is high, possibly by as much as .03 or .04. The undetermined loss is too low. If we assume the same improvement in this respect over 1922 at the Petree process factories as at the others, the average would be 0.55 instead of 0.48. The recovery is too high, possibly by as much as 0.21. It is unfortunate that these discrepancies, preventing direct comparisons exist, yet by taking into consideration their probable maximum size, which has been arrived at through careful consideration of all available data, fairly satisfactory comparisons can be made.

Examination of the figures shows that throughout this two year period there has been improvement in first expressed juice purity, greater improvement in mixed juice purity and still greater improvement in the purity of the syrup. Undetermined losses have steadily decreased as have also losses in molasses. Material increases in the total recovery have resulted. The 1923 extraction while better than in 1922 is still between 0.2 and 0.25 below the 1921 standard.

In comparison with 1921 the improvement in 1923 first expressed juice purity is 0.83. On the basis of the 1921 quality of boiling house work this improvement in initial purity corresponds to an increase in recovery from 85.86 in 1921 to 86.52 in 1923. The 1923 recovery taking the figure at its face value is 88.77, or 102.60% or 86.52. If we reduce the 1923 recovery figure by the maximum it was estimated that data from Petree process factories could have affected it, it is still 88.56, or 102.36% of 86.52. This indicates that notwithstanding slightly lower extraction than in 1921, more efficient factory work, previously discussed in detail, has resulted in an improvement in recovery somewhere between a minimum of 2.36 and a maximum of 2.60%.

If we place a net value of \$100 per ton on sugar, according to the above, more efficient factory work in 1923 has produced additional sugar to a value of between \$2.36 and \$2.60 for each ton of sugar that would have been produced

with the 1921 quality of work. If we estimate the "cost of manufacture" at \$7.50 per ton, in comparison with 1921, this extra production has paid for about one-third of the cost of factory operation.

Increased production to the above extent is closely confirmed by comparisons on a quality ratio basis. Data for quality ratio and tons cane required per ton of sugar follow :

	Quality Ratio	Tons cane required	Net gain over 1921	
			Tons	Per cent
1921	8.414	8.605	.....	....
1922	8.448	8.617	0.022	0.36
1923	8.573	8.556	0.208	2.42

The gain shown in the above tabulation, 2.42%, coincides closely with that arrived at in the previous calculation, and is between the minimum and maximum values there shown.

In Table 9 the factories are ranked on the basis of a comparison of actual and calculated recoveries. Similar tables in previous synopses were termed "factory efficiency." Comparisons on this basis have never been entirely satisfactory because due allowances could not be made in the calculations for differences in syrup purities, and factories with low syrup purities were discriminated against. This was because the standard for molasses purity was below the point attained in practice. A few years ago the standard was changed from 35 to 30 gravity purity, thus accentuating the discrepancies. This year discrepancies have been reduced and the comparison placed on a much fairer basis by adopting as the standard 37.5, a figure approximately the present average molasses purity. On this basis the work of a factory reducing the molasses to 37.5 gravity purity and having no other losses in the boiling house would be represented by 100 in the second column. As it is possible to reduce molasses far below this purity, the figure 100 then, has no particular significance with reference to the possible quality of the work. With good low grade work and high extraction it is possible for a factory to have figures over 100 in both the second and third columns. While the discrepancies have been reduced, comparisons on this basis are not yet entirely free from criticism. This table is again presented, however, for want of a better method for ranking the factories on the basis of the entire factory work.

The calculations in this synopsis have been made by Mr. A. Brodie assisted by Mr. H. A. Cook.

TABLE NO. 9.

COMPARISON OF ACTUAL AND CALCULATED RECOVERIES.

The factories are arranged in the order of the ratio of their recovery to that resulting from 100% extraction, reducing the molasses to 37.5 gravity purity, and eliminating all other losses. Factories reporting a recovery of over 101% of the available (Table No. 6) are omitted from this tabulation.

No.	Factory	Milling	Boiling House	Over All
1	Hakalau.....	98.87	101.13	100.14
2	Hilo.....	98.60	100.60	99.37
3	Pepeekeo.....	98.02	101.04	99.25
4	Onomea.....	98.88	99.81	98.86
5	Pioneer.....	97.90	100.61	98.78
6	Kahuku.....	96.09	102.06	98.65
7	Oahu.....	97.85	99.95	98.15
8	Honolulu.....	97.35	100.29	97.92
9	Haw. Sug.....	97.73	99.90	97.87
10	Waialuku.....	97.55	99.43	97.42
11	Makee.....	97.36	99.14	96.85
12	Pauuhau.....	97.28	98.63	96.25
13	Waialua.....	97.25	98.58	96.23
14	Kilauea.....	97.11	98.64	96.15
15	Olaa.....	96.60	98.98	96.15
16	Koloa.....	96.86	98.63	96.13
17	Kohala.....	95.95	99.31	95.65
18	Honokaa.....	96.16	98.65	95.25
19	McBryde.....	96.48	98.22	95.15
20	Laupahoehoe.....	96.95	97.53	94.82
21	Kaiwiki.....	96.19	98.23	94.75
22	Waianae.....	96.68	97.59	94.71
23	Waiakea.....	96.00	97.69	94.20
24	Hutchinson.....	96.50	96.94	94.12
25	Hamakua.....	97.62	95.80	93.74
26	Kekaha.....	96.42	96.41	93.33
27	Haw. Agr.....	97.07	95.51	92.95
28	Kaeleku.....	94.86	96.65	92.00
29	Union Mill.....	93.16	96.98	90.85
30	Olewaia.....	98.24	91.96	90.57
31	Niulii.....	91.79	97.48	89.99
32	Hawi.....	95.77	92.23	88.76
33	Halawa.....	92.86	92.72	86.50

FACTORY	POUNDS POLARIZATION PER TON OF CANE					POLARIZATION PER 100 CANE					POLARIZATION PER 100 POLARIZATION OF CANE					Syrup Purity	FACTORY			
	Bagasse	Press Cake	Molasses	Other Known	Undetermined	TOTAL	Bagasse	Press Cake	Molasses	Other Known	Undetermined	TOTAL	Bagasse	Press Cake	Molasses			Other Known	Undetermined	TOTAL
H. C. & S. Co.	8.4	0.2	16.6	...	-2.2	23.0*	0.42	0.01	0.83	...	-0.11	1.15*	3.02	0.09	5.92	...	-0.81	9.22*	87.65	H. C. & S. Co.
Oahu.....	5.8	0.8	19.6	...	1.2	27.4*	0.29	0.04	0.98	...	0.06	1.37*	2.15	0.26	7.14	...	0.43	9.98*	86.80	Oahu
Kwa.....	7.2	0.8	20.2	...	0.2	28.4*	0.36	0.04	1.01	...	0.01	1.42*	2.90	0.36	8.15	...	0.10	11.51*	82.96	Ewa
Waialua.....	7.2	1.4	22.8	...	1.8	33.2	0.36	0.07	1.14	...	0.09	1.66	2.75	0.57	8.73	...	0.68	12.73	84.60	Waialua
Pioneer.....	5.8	0.8	18.2	...	1.2	26.0	0.29	0.04	0.91	...	0.06	1.30	2.10	0.31	6.65	...	0.46	86.16	86.16	Pioneer
Maui Agr....	6.6	...	17.0	...	-3.6	20.0*	0.33	...	0.85	...	-0.18	1.00*	2.44	...	6.36	...	-1.36	7.44*	87.19	Maui Agr.
Olaa.....	8.4	1.2	20.0	...	0.8	30.4	0.42	0.06	1.00	...	0.04	1.52	3.40	0.49	8.14	...	0.35	12.38	85.8	Olaa
Haw. Sug....	6.4	2.4	18.4	...	0.4	27.6	0.32	0.12	0.92	...	0.02	1.38	2.27	0.85	6.47	...	0.17	9.76	86.30	Haw. Sug.
Onomea.....	2.8	0.2	15.6	...	2.0	20.6	0.14	0.01	0.78	...	0.10	1.03	1.12	0.07	6.30	...	0.81	8.90	87.34	Onomea
Honolulu....	9.2	0.4	30.8	0.8	...	...	0.46	0.02	1.54	0.04	...	...	3.41	0.15	11.48	0.31	...	...	85.23	Honolulu
Hakalau....	2.8	0.4	15.4	...	1.2	19.8	0.14	0.02	0.77	...	0.06	0.99	1.13	0.13	6.15	...	0.51	7.92	85.87	Hakalau
Kekaha.....	9.8	2.2	19.8	...	4.6	36.4	0.49	0.11	0.99	...	0.23	1.82	3.38	0.82	7.23	...	1.70	13.33	87.27	Kekaha
Lihue.....	5.6	0.6	18.8	...	0.4	25.4*	0.28	0.03	0.94	...	0.02	1.27*	2.31	0.25	7.62	...	0.17	10.35*	83.24	Lihue
Haw. Agr....	7.0	1.8	18.2	...	5.4	32.4	0.35*	0.09	0.91	...	0.26	1.61	2.93	0.76	7.69	...	2.19	13.57	87.61	Haw. Agr.
Hilo.....	3.4	0.6	16.4	...	0.6	21.0	0.17	0.03	0.82	...	0.03	1.05	1.40	0.27	6.81	...	0.22	8.70	85.91	Hilo
McBryde....	9.0	0.8	23.8	...	0.2	33.8	0.45	0.04	1.19	...	0.01	1.69	3.52	0.28	9.22	...	0.10	13.12	85.54	McBryde
Wailuku....	6.4	0.4	19.0	...	0.2	26.0	0.32	0.02	0.95	...	0.01	1.30	2.45	0.19	7.29	...	0.08	10.61	87.0	Wailuku
Makee.....	6.4	0.8	20.0	...	5.6	32.8	0.32	0.04	1.00	...	0.28	1.64	2.64	0.30	8.34	...	2.34	13.62	83.21	Makee
Laupahoehoe	7.6	0.4	20.8	...	2.2	31.0	0.28	0.02	1.04	...	0.11	1.55	3.05	0.17	8.27	...	0.84	12.33	86.95	Laupahoehoe
Honokaa....	8.6	1.0	19.4	...	1.0	30.0	0.43	0.05	0.97	...	0.05	1.50	3.84	0.42	8.66	...	0.42	13.34	84.80	Honokaa
Pepeekeo....	4.8	0.4	14.2	...	2.4	21.8	0.21	0.02	0.71	...	0.12	1.09	1.98	0.13	5.72	...	1.00	8.83	86.0	Pepeekeo
Kahuku.....	9.0	2.2	19.4	...	2.6	33.2	0.45	0.11	0.97	...	0.13	1.66	3.91	0.91	8.36	...	1.08	14.26	80.78	Kahuku
Hamakua....	5.8	4.0	18.0	...	5.8	33.6	0.29	0.20	0.90	...	0.29	1.68	2.38	1.63	7.39	...	2.40	13.80	86.14	Hamakua
Hononu.....	6.6	0.8	15.8	...	1.0	24.2	0.33	0.04	0.79	...	0.05	1.21	2.65	0.34	6.39	...	0.40	9.78	86.3	Hononu
Koloa.....	7.8	2.6	24.4	...	4.0	38.8	0.39	0.13	1.22	...	0.20	1.94	3.14	1.69	9.92	...	1.64	15.79	81.6	Koloa
Paauhau....	6.2	1.0	17.4	...	2.0	26.6	0.31	0.05	0.87	...	0.10	1.33	2.72	0.44	7.61	...	0.83	11.60	86.1	Paauhau
Waiakea....	10.0	1.2	16.2	...	6.0	33.4	0.50	0.06	0.81	...	0.30	1.67	4.90	0.45	6.49	...	2.44	13.38	86.34	Waiakea
Hutchinson..	7.6	0.8	19.8	...	3.6	30.8	0.28	0.04	0.94	...	0.18	1.54	3.30	0.35	8.64	...	1.69	14.18	85.32	Hutchinson
Hawi.....	11.6	1.6	29.4	...	7.6	50.2	0.58	0.08	1.47	...	0.38	2.51	4.23	0.57	10.75	...	2.75	18.30	86.40	Hawi
Waianae....	8.6	1.2	...	...	29.0	38.8	0.43	0.06	...	...	1.45	1.94	3.32	0.49	...	...	11.10	14.91	83.70	Waianae
Kaiwiki.....	9.2	2.2	18.2	...	2.0	32.6	0.46	0.11	0.96	...	0.10	1.63	3.81	0.93	8.03	...	0.85	13.62	85.21	Kaiwiki
Kohala.....	9.8	1.6	19.4	...	0.6	31.4	0.49	0.08	0.97	...	0.03	1.57	4.05	0.68	7.98	...	0.28	12.99	85.05	Kohala
Kilauea....	6.6	2.0	19.6	...	6.6	34.8	0.33	0.10	0.98	...	0.23	1.74	2.89	0.90	8.65	...	2.91	15.35	81.6	Kilauea
Kaeleku....	12.0	1.6	24.6	...	3.0	41.2	0.60	0.08	1.23	...	0.15	2.06	5.14	0.64	10.50	...	1.30	17.38	83.36	Kaeleku
Halawa.....	16.6	2.0	...	...	30.2	48.8	0.83	0.10	...	...	1.51	2.44	7.14	0.85	...	...	13.10	21.09	85.21	Halawa
Niuli.....	19.0	0.8	...	...	22.4	42.2	0.85	0.04	...	...	1.12	2.11	8.21	0.33	...	...	9.68	18.22	85.04	Niuli
Waima.....	6.2	1.0	...	...	21.6	28.8*	0.31	0.05	...	...	1.08	1.44*	2.41	0.41	...	...	8.52	11.34*	83.57	Waima
Union Mill..	15.8	3.2	20.8	...	0.2	40.0	0.79	0.16	1.04	...	0.01	2.00	6.84	1.39	9.05	...	0.12	17.40	84.97	Union Mill
Olowalu....	4.6	0.6	32.4	...	11.2	48.8	0.23	0.03	1.62	...	0.56	2.44	1.76	0.19	12.37	...	4.31	18.63	83.7	Olowalu

* A comparison of the available sucrose in the juice with the amount recovered in the boiling-house indicates that there is probably an error in some of the results reported from this factory.

† Sucrose.

Sugar Prices.

96° Centrifugals for the Period September 16 to December 15, 1923.

Date	Per Pound	Per Ton	Remarks
Sept. 19, 1923	6.905¢	\$138.10	Cubas, 6.78, 7.03.
“ 20	7.28	145.60	Cubas.
“ 24	7.41	148.20	Cubas.
“ 25	7.53	150.60	Cubas.
“ 27	7.78	155.60	Cubas.
Oct. 23	7.405	148.10	Cubas, 7.53, 7.28.
“ 24	7.34	146.80	Cubas.
“ 25	7.28	145.60	Cubas.
“ 31	7.09	141.80	Cubas.
Nov. 2	6.91	138.20	Cubas.
“ 9	7.16	143.20	Cubas.
“ 21	7.3433	146.86	Cubas, 7.28, 7.34, 7.41.
Dec. 10	7.28	145.60	Cubas.
“ 12	7.335	146.70	Cubas, 7.41, 7.26.

THE HAWAIIAN PLANTERS' RECORD

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Number 2

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Early Efforts to Grow Sugar Cane Seedlings in Hawaii

"In all of these experiments patience is required," said James E. Teschemaker, of Boston, in a letter he wrote the Royal Hawaiian Agricultural Society in 1852, urging that body to take steps toward producing sugar cane seedlings. He cautioned that disappointment must not be felt if initial efforts failed, and pleaded for perseverance in the work of "causing the sugar cane to bear seed." He held the idea that special manurial treatments would lessen the vegetative growth and result in the production of viable seed, and he outlined experiments which he advocated in this connection. He ended his letter by saying that the probability was great that through growing seedlings much better varieties could be obtained than those then cultivated.

The Royal Hawaiian Agricultural Society at their first annual meeting in 1851 had resolved, "That a committee be appointed to institute experiments with a view to obtain plants from the seed of sugar cane, and to procure information on the subject." (The committee appointed were E. P. Bond, chairman; D. Baldwin, G. A. Lathrop, B. Pitman.) Apparently this committee had addressed Mr. Teschemaker as one who could speak with authority on their problems.

At the annual meeting of June, 1853, Mr. Bond reported as follows:

As Chairman of the committee to obtain plants from the seed of the sugar cane, I regret to be compelled a second time to present an unsatisfactory report.

On Hawaii Mr. Pitman has been prevented from making any experiments to test the process suggested by Mr. Teschemaker, for obtaining germinating seed from the cane, he having been unable to find a suitable spot in his neighborhood in which to attempt them.

I subjoin a letter received from Mr. Pitman, from which it will be seen that he has little faith in the practical advantages which would follow success.

From Dr. Baldwin, of Maui, and Dr. Lathrop, of Oahu, the other members of the committee, I have received no report.

On Kauai, I have made some experiments, following as nearly as possible the directions of Mr. Teschemaker, but I am sorry to say that they have as yet met with no favorable result. Still the pursuit is an interesting one, and I do not yet despair of final success.

I am by no means sure that the varieties of cane which we have are the best possible for our soil and climate. The agriculture of the world may be enriched by the introduction of new varieties of the cane.

This is a subject well worthy of the continued attention of the Royal Hawaiian Agricultural Society.

In the following year lack of success was again reported.

It is of great interest to learn of these early attempts at sugar cane seedling production in Hawaii, made as they were some thirty-five years before Soltwedel in Java in 1888, and Harrison and Bovell in Barbados in 1899, demonstrated the practicability of producing new varieties of cane from seed.

That there was actually earlier proof of the fertility of cane seed is shown by Noel Deerr in *Cane Sugar*, who says:

The fertility of the cane was definitely established in May of 1858,* when an overseer at the Highlands Plantation in Barbados saw and recognized seedling canes growing in the field. He reported their presence to Mr. J. W. Parris, the proprietor, who grew these self-sown seedlings to maturity, and afterwards grew four and a half acres of seedling canes. This discovery was put on record in the Barbados Liberal of February 12th, 1859, and was confirmed shortly afterwards by several local planters. The question was followed up by Drumm in Barbados, who experimented in hybridization, and devised the method of "bagging", the inflorescence referred to later. It does not appear certain that Drumm ever obtained hybrids, though his communications on the matter in the local Barbados press obtained wide publicity in the Sugar Cane, the Produce Markets Review, and in Australia.

In 1862 self-sown seedlings were also observed in Java; in 1871 these were obtained of intent by Le Merle in Reunion, and about the same time the Baron da Villa Franca wrote as if the fertility of the cane was a matter of common knowledge in Brazil. All these observations, however, were forgotten, and systematic research work dates from the re-discovery by Soltwedel in Java in 1888 and by Harrison and Bovell in Barbados in 1889.

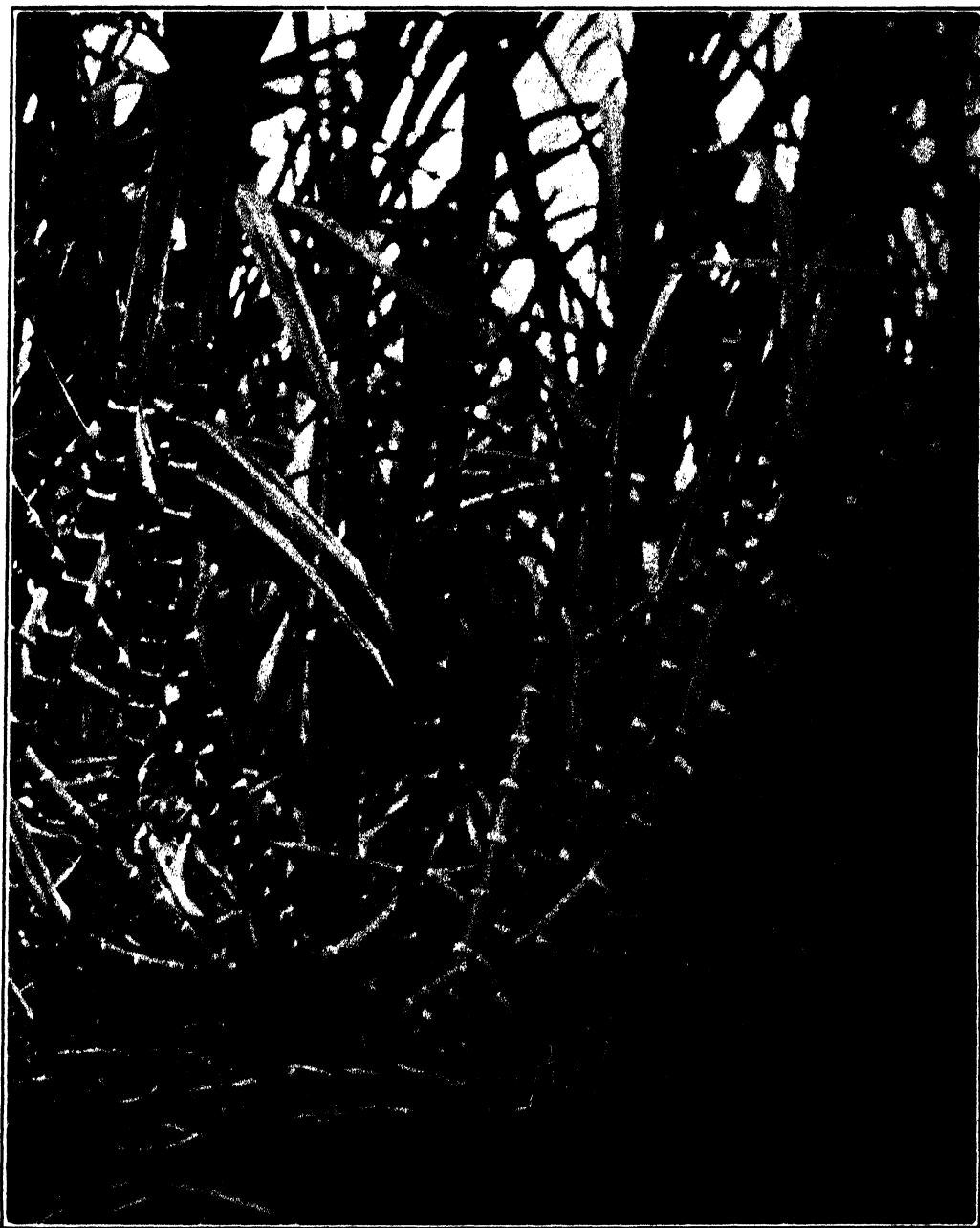
Long previous to this, however, it is possible that seedling selection had been practised by primitive peoples, and it is almost certain that it was as seedlings that some of the cultivated varieties of cane were originally segregated by some intelligent and observant savage. Mr. Muir has told the writer that he saw, during his travels in search of a parasite for the Hawaiian beetle borer, such a process obtaining amongst the New Guinea natives. A seedling cane, or any newly introduced sexual variant, is then in no wise different from any of the older varieties, the sexual origin of which has been forgotten.

Yield of Sugar in the Territory of Hawaii for Crop of 1923

	Acres	Tons Sugar Harvested	Lbs. Sugar per Acre	Tons Sugar per Acre
Total yield	114,286.16	530,957.64255	9,292	4.646
Irrigated Plantations	60,280.87	342,451.10055	11,362	5.681
Unirrigated Plantations	54,005.29	188,506.54200	6,982	3.491
Hawaii	53,055.29	186,085.0735	7,014	3.507
Oahu	22,377.58	138,472.0408	12,376	6.188
Kauai	21,470.07	94,780.8035	8,830	4.415
Maui	17,383.22	111,619.72475	12,842	6.421

* A statement in the "Transactions of the Agricultural and Horticultural Society of India" (1838, 2, 393), reads as if cane seedlings had even then been experimentally propagated in that country. In Ure's "Dictionary of Arts and Manufactures" of date c. 1845, the statement is also made that "in India it grows to seed". I have been unable to confirm or refute these statements.

D 1135 at Pahala



D 1135 growing at Hawaiian Agricultural Company—2,100 feet elevation. On this plantation D 1135 seems to do remarkably well at this elevation, as can be seen by noting the large size of the stalks.

Remarkable Growth of Fig Trees in a Forest Planting

Three of the Australian figs are making such remarkable showings in forest plantings in various parts of these Islands that we can now safely conclude that they are going to become important components of our future forests.

The Moreton Bay fig is proving a favorite for planting as a shade tree in villages, about camps and near tanks and water troughs in pastures. Some remarkable specimens may now be seen in such situations at many points on Oahu,



Ficus macrophylla in forest planting in the lands of Helemano.

Molokai and Hawaii. These plants have in many cases, no doubt, received considerable care and attention to which their good appearance may in part be attributed. In none of these situations, however, has a plant of *F. macrophylla* made growth equal to that shown by some trees of this species planted out by Mr. McEldowney in the forest at about 1,100 feet elevation in the lands of Helemano

on Oahu. Seedlings 12 to 15 inches tall planted out in August, 1922, attained a height of 5 to 7 feet by December, 1923.

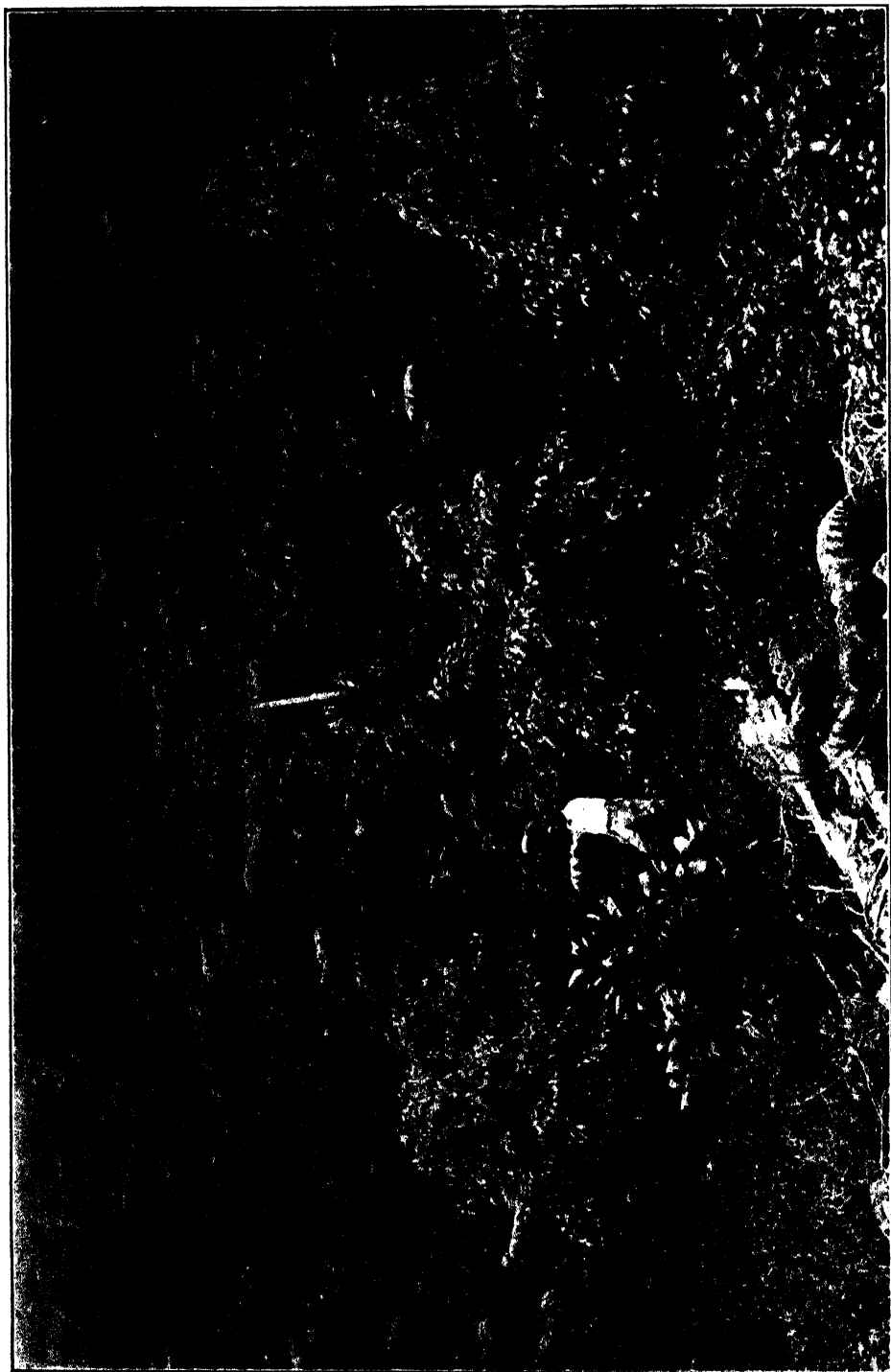
The Port Jackson fig, *Ficus rubiginosa*, is a close second to the Moreton Bay fig in numbers of trees being set out. From the results thus far obtained, it would seem that this tree is going to prove quite equal, if not superior, to the Moreton Bay for forestry purposes in many districts: however, it is, as yet, too



Ficus rubiginosa. This specimen was a seedling twelve inches tall when planted out in August, 1922. The photograph was taken sixteen months later.

early to advance a final conclusion in this matter. In the forest planting in Helemano, the Port Jackson fig has made a showing comparable to that displayed by the Moreton Bay, as may be judged from the accompanying pictures.

While the two figs mentioned have made very remarkable growth, their performances are paled by the spectacular display of vigor exhibited by another Australian fig, *F. glomerata*, included in the same planting. This fig was not



The tree on Mr. McEldowney's left and the one towards which he is looking are specimens of *Ficus glomerata*. A third tree of this species is seen at the extreme right of the picture and nearly in line with the other two. The tree in front of Mr. McEldowney is the specimen of *F. macrophylla* shown in our first illustration.

represented by any specimens in Hawaii prior to our introduction and we did not gain a correct idea of the nature of the tree from the published descriptions. We were not expecting much of it and consequently its behavior under Hawaiian conditions has proven a most agreeable surprise. Seedlings 15 inches tall planted out in August, 1922, attained a height of 10 to 15 feet by December, 1923. The foliage of this tree is more open than that of the Moreton Bay and Port Jackson figs and it will, therefore, encourage a heavier undergrowth than will these closer-leaved forms. It drops its foliage for a very short period each year while the other two figs retain a heavy foliage at all times. Our trees of *F. glomerata* were grown from seed collected by Mr. Pemberton in Northern Australia. Our stock of young trees was quite limited and quickly exhausted. We are striving to secure additional seed by correspondence, but, as yet, have achieved no success in this direction. It is extremely difficult to get seeds of wild figs collected in quantity by correspondents who know the trees well enough to detect the species from which seed is desired.

Ficus glomerata has a much wider geographical distribution than either the Moreton Bay or Port Jackson figs. The two last named trees are confined to Australia while *F. glomerata* ranges from the Himalayas in Northern India to Queensland in Australia. It is described in botanical works as a "middle sized or large tree". It is said to grow by choice "in ravines, on the banks of rivers and in damp places". We consider it one of the best "prospects" now under trial for planting in the wet regions where we wish to build a rain forest.

H. L. L.

Rat Control*

By C. E. PEMBERTON.

Rat control by the poison method on the plantation of the Honokaa Sugar Co. has now been in active operation for over a year. It has been a commercial success though there has been by no means an eradication of the rat. Rats are still present in fair numbers in spots and unless the application of poison is vigorously continued there will undoubtedly be a reversion to the old conditions in a short time. This fact is fully recognized on the plantation and the poison campaign will most likely be carried on even more intensively in the future. The probable improvement in the poison used, the greater quantity applied, and the ever increasing knowledge of the habits of the rat, during the growing season of the cane and during and immediately after the harvest, has resulted in an improved understanding of when to apply poison and where to place it.

The feeling that wholesale poisoning has checked the rats to such an extent that a worth-while saving in sugar has resulted and that a very large reduction

* Presented at the meeting of the Association of Hawaiian Sugar Technologists, October, 1923.

in the rat population has actually occurred, is based on a combination of circumstances. The most gratifying fact of all is the very considerable reduction in the amount of rat-damaged cane in the 1923 crop as compared with previous crops. The 1923 crop is finally off and it is now possible to tabulate data secured for both the 1922 and 1923 crops during the entire period of harvest both years. The difference in damage, though recognized as each field came off this year, is strongly indicated in comparing the results of percentage counts made in each field for both crops as shown in Tables 1 and 2. Table 2, giving percentages obtained by Honokaa Sugar Company in 1922, shows an average rat damage to the cane for that year of 19 per cent. This crop had not been poisoned excepting in spots in preliminary experiments. Table 1, showing counts made by the writer in each field of the 1923 crop, gives an average damage for all of the fields of 4.29 per cent, ranging from no injury in some fields to 11.7 per cent where the worst injury occurred. This average was computed from an examination of 404,100 sticks of cane, taken in all sections of each field as it was harvested, and should fall close to the actual damage that occurred. Thus the unpoisoned 1922 crop was found by Honokaa Sugar Company to be rat damaged to the extent of 19 per cent while the poisoned 1923 crop was only injured to the amount of 4.29 per cent. This justifies the continuance of the poison method of control.

Apart from these data there is the strong testimony of every individual living about the plantation, respecting the general scarcity of rats about houses and in the fields, as compared with former years. The statements of the skilled field overseers should be recognized. Without exception they have repeatedly remarked on the almost complete absence of rats appearing from beneath the piles of cane along the flumes during the harvesting season. Very few rats have been so observed this year, and in many fields none at all. Last year, and in previous years, they are said to have been always very numerous beneath cut cane which had been left piled up overnight along the flumes. At the commencement of laboratory investigations of the rat in 1922, live rats for experimental purposes were readily obtained in quantity while the cane was being flumed. By the beginning of 1923 they were not so common and as months went by it became increasingly difficult to secure live rats, while during the past four months it has not been possible to secure any in this manner, though single individuals have been occasionally seen, and from 15 to 30 a day are usually caught in several hundred steel snap-traps operated daily.

Many individual cases could be cited of rat scarcity this year in fields notoriously infested during the past, and many interesting statements from even disinterested parties regarding comparisons of present with past conditions could be given. It will be sufficient here to cite one instance. In 1921, a certain slope in Field 29 (mature cane) was fenced in with galvanized iron sheets to the extent of about $1\frac{1}{2}$ acres. This cane was then fired, cut and piled up within the enclosure. The following morning the cane was flumed and a total of 132 rats that ran out from beneath this cane were killed. This year, the same field was again harvested and not a single rat was seen under any of the piled up cane as it was flumed either at this particular spot or in any part of the whole field.

Rat burrows within the cane fields and on adjacent land are comparatively scarce this year. In 1922, it was an easy matter to locate a dozen or more in close proximity in any rat-infested field. Burrows can be found at present, but only after considerable search in most fields.

Without referring in further detail to the proof of beneficial results in the rat-poison campaign at Honokaa, we can reasonably assume that the results in 1923 have come from the persistent and intelligent application of poison. Rats are secretive in their habits, exhibiting great variation in choice of residence and food and are sometimes known to be strongly migratory under unknown causes. In spite of this, however, it would indeed be a most remarkable coincidence if the greatly reduced evidence of their presence and the positive reduction in their injury to cane at Honokaa were induced by causes other than wholesale poisoning.

We have always been confronted with the difficulty of finding dead rats. Where poison has been placed in quantity in fields known to harbor a large rat population, dead rats in reasonable proportion to the quantity of poison observed to be taken, are not found. Some dead rats and many dead mice are frequently seen, but not as many as would naturally be expected. What becomes of the poisoned rats has been somewhat of a problem. Exhaustive laboratory experiments with live rats have conclusively shown that the poison-baits when eaten do actually kill the average rat, and it is a fact beyond dispute that rodents in the field do eat the poison even more readily and in greater quantity than when confined in cages. Some definite observations in the field have been made to explain this in part. The mongoose, which is quite common in Hamakua, will eat dead rodents, either poisoned or trapped. Laboratory experiments show that the consumed poisoned rodents have no injurious effect upon the mongoose, where the rats or mice have died from eating strychnine or barium-carbonate. Poisoned rodents have been placed in the cane and frequently missed in 24 hours. Mongoose excrement filled with rodent hair is a common occurrence in the Honokaa cane fields. This, then, partly accounts for the disappearance of many rats that die in the open before getting away to their burrows. In the cane fields the field rat and mouse live in burrows in the ground. The rat burrows often extend to several feet in depth and frequently ramify into intricate branching galleries for from one to three yards in distance. This enables a poisoned rat to get away and die underground completely hidden from view. In the early stages of the poison campaign in 1922, when rats were very numerous, poisoned fields often smelled of decaying flesh, without otherwise showing evidences of dead rats. This may perhaps account for the scarcity of dead rats when fields were poisoned. It should be stated, however, that some of these burrows have been dug out without finding dead rats. As barium-carbonate has been the base in most of the baits used, the rat has had full time to hide after eating it, for this poison usually takes from 6 hours to 3 or 4 days to kill after being eaten. Where strychnine has been used dead rodents have been more frequently observed. This acts quickly after being taken, and rats and mice, particularly the latter, usually do not get far from the bait after taking part of it.

After testing numerous poisons at Honokaa, barium-carbonate and strychnine have been found to be the most practicable. The results have mostly been

obtained with barium-carbonate. As noted in Table 3, there has been only one large application of strychnine. This was in December, 1922. Most of the results on the 1923 crop had already been accomplished with barium-carbonate by the time this strychnine was applied. Both are splendid poisons for rats and mice, if intelligently and generously used. Barium-carbonate, a fine white powder, has been applied mostly in combination with wheat middlings in a proportion of one part barium-carbonate to three parts middlings. This is thoroughly mixed, moistened, kneaded to a heavy dough, rolled into sheets, cut into small flat circular cakes one-half inch in diameter, dried until hard and coated with paraffin to prevent mould development and general deterioration. This mixture has also been applied to some extent in the powdered, dry, uncaked condition. It is then put out in 4-gram paper packages or torpedoes, the paper being paraffined. The bulk of the poison applied on the 1923 crop, however, was in the form of the barium-carbonate paraffine-coated cake.

The strychnine has been used as a coating on whole wheat, using one ounce of strychnine (alkaloid) to 25 pounds of grain. The strychnine (alkaloid) comes finely powdered. It is first mixed with water, starch, and sometimes saccharine, salt and baking soda, into a heavy, creamy liquid and then poured over the wheat. This is then thoroughly mixed until the wheat is all wet. The grain is then dried and ready for use. Strychnine-wheat has been put out, with good results, in paraffin paper torpedoes using from $\frac{1}{4}$ to 1 ounce of grain per bait. It is readily taken by both rats and mice. Strychnine, so used, though a good poison for the average rodent, does not always kill. It either varies in toxicity, as purchased, or rats are resistant to it in widely varying degrees. A good many rats, in captivity, have been fed strychnine-wheat in quantity, without visible discomfort, while others, often large and vigorous, have been quickly killed on small amounts, not exceeding $\frac{1}{2}$ ounce. Barium-carbonate, however, seems fatal to all rats. Both strychnine-wheat and barium-carbonate baits are quickly fatal to mice. Rats are slower to die. Mice have been killed repeatedly with one-half dozen grains of strychnine-wheat. Sometimes as few as 2 grains have proven fatal. Two or three grains of rolled oats dusted with barium-carbonate will generally kill a mouse. Some rats have eaten as much as 6 ounces of strychnine-wheat without fatal results while others die in a few hours after taking $\frac{1}{2}$ ounce of it. Usually a few grains, in weight, of the barium-carbonate baits, proves fatal to rats.

Of late, barium-carbonate has been tested in the laboratory mixed dry with rolled grain and fed to rats in this form. Rolled oats treated in this manner has given splendid results. Being simply the dry, loose, rolled grain, dusted with barium-carbonate, using one part barium-carbonate to four parts grain, it seems to be a more natural rodent food than the more complicated mixtures. Rats take it well. This is really the big point in rodent poison work. Plenty of known poisons are available that will kill, but the biggest problem is to make it palatable or as nearly natural in attractiveness as possible. The barium-carbonate dusted rolled grain, in dry form, being cheap, easily mixed and safely stored without deterioration, may in time supplant the more complicated cake formula or strychnine-wheat form of poison at Honokaa. Field tests during 1924 will

prove its usefulness. It requires no heating, cooking or drying. The poison, being of a fine powdery nature, clings beautifully to the rough rolled grain, particularly rolled oats. When wrapped in 4-gram, paraffined paper torpedoes it makes a very satisfactory, cheap and easily distributed bait. Rats frequently carry away these paper packages. They are often missed in the field the day following application. In one case such a package was found within a rat's nest in the top of a Pandanus tree, the contents of the package being consumed and the nest vacated.

Other poisons have been tested in the laboratory with varying results. These included extract of squills, phosphorus, rat-typhoid virus in three forms, arsenic and cyanide of potassium. They all seem to have disadvantages over barium-carbonate or strychnine. Some gave no results of value. Phosphorus combined with wheat middlings and made into a cake gave fair results, but its odor, inflammable nature, expense and deteriorating qualities after mixing, are against it.

Barium-carbonate and strychnine have been used as rodent poisons for many years in various parts of the world and in most places are recommended. The U. S. Bureau of Biological Survey, in a recent publication, strongly favors barium-carbonate. The novel idea at Honokaa in the application of these poisons, is the scheme of waterproofing, whereby the cake-bait is paraffin-coated and the loose, dry baits wrapped in paraffined paper. This has been a great help when large quantities of the poison are mixed at one time and stored for future use, and it also tends to keep the poison fresh after being placed in the field.

Barium-carbonate costs from \$65.00 to \$70.00 per ton, and strychnine in the alkaloid form costs about \$1.10 per ounce. At these rates it has cost the Honokaa Sugar Company about \$60.00 per ton more to manufacture strychnine-wheat than barium-carbonate baits. Both costs are a great deal under the market quotations on commercial rat poisons manufactured by various firms in the States. Poisons manufactured at home also have the advantage of being fresh. There is nothing complex in their preparation. Strychnine-wheat, if made from the alkaloid, which is the best form, is liable to deteriorate rapidly if handled much or if reached by ants, weevils or other insects. The strychnine is present simply as minute crystals clinging to the surface of the grain. If these become disturbed much by insects, etc., they may be easily separated from the grain and much of the bait becomes worthless. For these reasons strychnine-wheat should be best if made on the plantations and used immediately. A careful supervision over the preparation of these simple mixtures is all that is necessary.

The good results in rat control at Honokaa Sugar Company have been obtained through constant and skilled attention in the manufacture of every pound of poison, and the large application of this poison three or more times a year in every part of the entire plantation, which comprises not only the cane but every gulch, rock pile, building, ditch, roadside and grassy or waste area. The aim has been to place about one set of poison every 10 or 15 feet. Most of the cane fields of the 1923 crop received only three applications, but, as shown in Table 3, some were covered four times and a few received a fifth treatment. The first application is given after the cane is well up and sufficiently advanced to show sticks bearing considerable sugar. It is then that the rats appear to move into the fields. It has also been found important to apply poison in waste areas,

gulches, rock piles, roadsides, ditches, etc., adjacent to cane fields immediately after the cane is harvested. The rats which were housed in their burrows within the standing cane, move out of the fields as soon as the cane is cut. Their food and cover is gone. Proof of this has been positively established in various ways. These moving, hungry rats, first accumulate in the lands adjacent to the cut fields. The denser the vegetation in these adjacent areas the more suitable it is for the rats and the longer they are liable to remain. If it is in cane they will naturally concentrate there, but even rough, sparsely overgrown areas will harbor many of these migrating rats for some weeks at least. It has been found that trapping in such places immediately following harvest, will yield rats in greater quantity for a time than would be the case in the cane before it was cut, and also that poison placed in such localities is taken to a considerable extent.

The total cost at Honokaa Sugar Company to manufacture and apply the poison, together with the constant operation of several hundred traps daily, amounted to about \$5,000 for the past year. Prior to 1922, the cost per year of trapping alone ran from \$5,000 to \$7,000 with no visible results. During the years 1914 to 1922 Honokaa Sugar Company and Pacific Sugar Mill trapped a total of 1,138,011 rats; actually tons of rats, yet no real return for the money could be noted. This huge total only represented a very small portion of the rat population in the community, for these traps could only cover a small fraction of about 14,000 acres constituting the two places. The aim in the poison campaign, however, has been to cover every acre of this area not once, but, as above stated, three or more times per year. As the annual progeny of a **single** pair of rats in a tropic or semi-tropic region can be as high as 800, in the **absence** of famine, floods and natural enemies, we can expect the progeny to be **large** under Hamakua conditions where rats seem to thrive, and any control by poisoning can only hope to be successful by poisoning several times a year rather than once. With an average gestation period of 21 days, and reproduction possible at the age of three months, an average of six litters per year and an average of eight young per litter, we have a pest to deal with that is enormously prolific and whose increase to positive swarms in our cane fields is only prevented by a scarcity in proteid foods and by complex minor causes of which we know nothing. One killing a year, then, is greatly insufficient.

The actual loss in sugar in cane fields where rats are numerous is surprisingly greater than is generally supposed. The loss not only lies in the particular joints of the stick which have been eaten into, but a general deterioration usually occurs in the whole stick and the nearer the eaten joints the more affected the juice becomes. During August and September, 1923, samples of rat-eaten and sound canes were taken from cane fields at Honokaa and submitted to Mr. A. Fries, Chemist of Honokaa Sugar Company and Pacific Sugar Mill, for comparative analyses. Eighteen separate lots were cut, in as many days, and separate analyses were made of the sound and rat-eaten lots each day. In every case entire sticks were cut and the total extracted juice was used. Only slightly damaged cane was selected for the tests, usually bearing only from one to three injured joints, and only live, growing, 15 months old cane was cut. The results, as given in Table 4, are very interesting. The average from the eighteen lots showed that in the sound canes the yield of commercial sugar per ton of cane

amounted to 230.3 pounds of sugar, as against 195.8 pounds or 14.9 per cent, in the rat damaged lots, or 8.77 tons of cane to the ton of sugar in the sound lots and 10.41 tons of cane to the ton of sugar in the injured lots. As stated above, these data were secured from cane only slightly rat-damaged. The sugar loss in average damaged cane will be greater. As already stated, the rat-damage at Honokaa in the 1923 crop amounted to 4.29 per cent. If this 4.29 per cent were only slightly damaged as in the eighteen samples, there would be a 14.9 per cent sugar loss in 4.29 per cent of the total crop. Actually, it has been greater than this even under the present control. As computed by Mr. Haldeen, former chemist at Honokaa Sugar Company, when rats were out of control on this plantation, the damage was generally so great that rat-eaten sticks showed about a 50 per cent sugar loss. Assuming the fields, then, to show about 25 per cent of the sticks injured, or even 19 per cent as in 1922, a 50 per cent sugar loss in the sticks injured would bring an actual loss in the whole crop of from 10 to 12 per cent of the potential available sugar. In the poisoned 1923 crop this falls to about 1 per cent, which indicates that rat control by poisoning has been worth while, if only these data are considered.

A difference of 10 per cent in sugar yield at Honokaa Sugar Company this year at 7-cent sugar amounts to from \$75,000 to \$80,000. In other words, I believe, and they believe, that there has been some \$70,000 to \$80,000 worth of sugar added to their bags through rat poisoning.

Apart from the deterioration in the juice in rat-eaten cane that comes to the mill, there has also been a total loss in much cane that is killed outright in the fields through heavy rat damage. This cane never reaches the mill, but is left dead on the field. The heavier the rat damage in any field the more dead cane is seen lying about after the harvest. This dead cane is caused by rats eating clear through the stick, usually near the base and a good deal of cane eaten partially through becomes broken off by the wind. A few estimates have been made of the amount of such dead cane lying in fields after harvest where rat damage had been heavy in the 1922 crop. By measuring the length of all the dead sticks lying in a given area showing average damage for the field, and assuming a certain average weight per foot of cane, a fairly close estimate could be made. Two fields were taken in 1922 which showed from 25 to 50 per cent rat damage in the live cane at the time of harvest. In one case it was found that about $11\frac{1}{3}$ tons per acre of dead cane remained in the field and in the other 38 tons per acre or above half the cane produced in this area.

Lastly, an important result in any rat campaign in Hamakua is the possibility that extensive reduction of rats will materially check the danger of bubonic plague infection among the inhabitants of the district. It is not expected that this disease will be stamped out nor is there any hope of entirely eliminating the rats, but unquestionably the fewer the rats, the less chances there are for human plague cases. This being primarily a rat disease, carried or disseminated so far as we know almost solely from rat to man by the rat flea, one of the largest factors in preventing its spread lies in greatly reducing the rat and coincidentally its flea. Control of the rat about the villages and camps only cannot help much, owing to their great migratory ability, which enables them to move into villages and camps overnight. Unfortunately, the very species of rat flea which is associated with the most plague-infected regions in India, is the same species commonly occurring on rats in Hamakua. Other regions in India where,

rats bear other species of fleas, but rarely this particular one, are said to be comparatively free of plague. Recent medical research in India has brought this point to light. This particular flea seems especially adapted for successfully transmitting plague from rat to man and in some way has reached Hawaii at an unknown date.

There has been one death from plague at Honokaa this year, the only one for the district in 1923, as against twelve in 1922, six of which occurred at Honokaa. The death this year was of the pneumonic type, which is plague in its worst form. Plague in Hamakua is fatal. In other countries it is not always fatal.

It is hoped that the demonstration in rat control by poisoning, that has been in operation at Honokaa during the past year and which is actively going on at present, will in time show such striking results that control will be undertaken along similar lines over all of Hamakua, and that such control, in cooperation with the Territorial Board of Health, whose activities relate to the determination of areas of plague infection, their disinfection, and the improvement of camp and village sanitation and structure to guard against plague entrance to dwellings, etc., will ultimately reduce the danger of human plague infection to a low minimum. There are grounds for such a hope.

TABLE I.

RAT DAMAGE TO CANE HONOKAA SUGAR COMPANY CROP 1923—POISONED.

Field	No. Sticks Examined	Per Cent Rat-Damaged
20	6,000	.96
30	22,000	6.20
38	20,500	10.60
13	8,000	.69
33a	6,000	2.60
18	25,000	1.74
1	4,000	1.47
1a	7,000	.90
37	8,000	5.60
26	36,000	5.20
34	20,000	8.90
36	22,600	11.70
12	11,000	2.30
7	11,000	.90
D	4,000	.00
29	25,000	9.60
25	25,000	6.00
6	12,000	.36
11	9,000	8.80
24	3,000	.00
5	6,000	1.90
17	7,000	.89
28	35,000	3.85
10	8,000	7.40
22	14,000	8.45
35	12,000	4.30
19	2,000	5.90
33	35,000	3.10
Total	404,100	Average 4.29

TABLE II.

RAT DAMAGE TO CANE HONOKAA SUGAR COMPANY CROP 1922—UNPOISONED.

Field	No. Sticks Examined	Per Cent Rat-Damaged
2	3,700	25.00
33	4,700	16.00
37B	1,000	23.50
Chow Choy Cont.	1,100	26.50
1	2,600	16.50
21	1,400	12.30
17	600	11.00
19	1,400	19.00
24	1,200	21.00
28	700	16.00
27	5,700	22.00
<hr/>		
Total	24,100	Average18.90

TABLE III.

RAT POISON APPLICATION HONOKAA SUGAR COMPANY CROP 1923.

Field	First Appl.	Poison Used	2nd Appl.	Poison Used	3rd Appl.	Poison Used	4th Appl.	Poison Used	5th Appl.	Poison Used
1a	6-17-22	Barium-carb. Cake	11- 7-22	Barium-carb. Cake	12-20-22	Strychnine Wheat				
5	5-22-22	"	11-11-22	"	12-21-22	"	2-22-23	Barium-carb. Cake		"
6	7-19-22	"	11- 9-22	"	12-21-22	"				
7	7-31-22	"	11- 8-22	"	12-22-22	"				
10	7-18-22	"	10-25-22	"	12-28-22	"	5-14-23	"		
11	7-19-22	"	10-30-22	"	12-22-22	"	5-12-23	"		
12	7-22-22	"	11- 4-22	"	12-23-22	"				
13	7-26-22	"	11- 6-22	"	12-24-22	"				
17	5-31-22	"	11- 2-22	"	12-20-22	"	5- 7-23	"		
18	5-25-22	"	10-30-22	"	12-19-22	"				
20	5-20-22	"	10-24-22	"	12-21-22	"				
25	6-15-22	"	10-20-22	"	12-27-22	"	4-30-23	"		
26	6-17-22	"	10-21-22	"	12-22-22	"	5-15-23	" and Flour		
28	6-26-22	"	10-23-22	"	12-24-22	"	4-18-23	Barium-carb. Cake	7-30-23	Barium-carb. Cake
29	6-30-22	"	10-19-22	"	12-27-22	"	2-11-23	Strychnine Wheat	7-30-23	"
30	7-12-22	"	10-13-22	"	12-22-22	"	6-25-23	"		
33a	5-29-22	"	10-23-22	"	12-19-22	"				
34	3-22-22	"	10-10-22	Strychnine Wheat	12- 8-22	"				
36	6-14-22	"	10-16-22	Barium-carb. Cake	12-30-22	"				
37	6-30-22	"	10- 4-22	"	12-22-22	"				
38	7- 8-22	"	9-30-22	"	12-18-22	"	3-28-23	"	6-22-23	"

TABLE IV.
ANALYSES OF RAT EATEN AND SOUND CANE.

Polarization in Cane Calculated from Analyses and Weights of Bagasse and Juice.
Juice expressed by Laboratory Hand Mill.

Date		Brix	Juice		Cane % Pol.	Yield of Comm.	Tons Cane
			Pol.	Purity		Sugar per Ton Cane (Pounds)	per Ton Sugar
August 20.....	R	16.53	14.00	84.7	11.68	203.2	9.84
	S	17.61	15.18	86.2	12.80	226.6	8.83
" 21.....	R	14.76	11.89	89.6	9.97	166.4	12.02
	S	17.70	15.63	88.3	12.99	231.8	8.52
" 22.....	R	18.00	15.64	86.9	13.36	238.0	8.40
	S	17.78	15.78	88.7	13.39	242.4	8.25
" 23.....	R	15.00	12.19	81.3	10.36	173.6	11.52
	S	16.00	13.71	85.7	11.65	205.2	9.75
" 30.....	R	17.10	14.68	85.9	12.14	213.0	9.34
	S	18.40	16.71	90.8	13.79	255.2	7.84
Sept. 1.....	R	16.42	13.51	82.3	11.26	190.8	10.48
	S	16.52	14.36	86.9	11.92	212.4	9.42
" 4.....	R	15.03	12.04	80.1	9.93	163.4	12.24
	S	16.81	14.69	87.4	12.19	218.2	9.17
" 4.....	R	13.95	10.90	78.1	9.28	149.0	13.43
	S	15.60	13.20	84.6	11.13	193.4	10.34
" 6.....	R	16.95	14.61	86.2	12.11	214.0	9.35
	S	18.84	16.96	90.0	14.22	261.0	7.66
" 6.....	R	14.10	11.13	78.9	9.41	152.8	13.09
	S	16.30	14.07	86.3	11.72	205.4	9.74
" 7.....	R	16.51	13.78	83.5	11.58	199.0	10.06
	S	17.16	14.89	86.8	12.39	220.6	9.07
" 13.....	R	16.50	14.06	85.2	11.77	206.0	9.71
	S	16.70	14.43 ^a	86.4	12.00	212.6	9.41
" 14.....	R	15.00	12.53	83.5	10.40	178.6	11.20
	S	19.10	17.13	89.7	14.28	261.4	7.65
" 15.....	R	16.13	13.88	86.1	11.71	206.0	9.71
	S	18.60	16.99	91.3	14.17	262.4	7.62
" 17.....	R	18.60	16.25	87.4	13.57	242.8	8.24
	S	17.45	15.46	88.6	12.96	234.8	8.52
" 18.....	R	16.45	13.66	83.0	11.25	192.2	10.40
	S	19.43	17.80	91.6	14.62	269.2	7.43
" 19.....	R	17.31	14.73	85.1	12.08	211.2	9.47
	S	16.80	14.74	87.7	12.38	222.0	9.01
" 20.....	R	17.32	15.23	87.9	12.48	224.4	8.91
	S	16.03	13.98	87.2	11.61	207.8	9.62

AVERAGES

Rat Eaten	16.23	13.59	83.73	11.35	195.8	10.41
Sound	17.38	15.32	88.15	12.79	230.3	8.77

The History of the Sugar Cane Variety H 109*

(Compiled from the publications and files of the Experiment Station by
H. P. Agee.)

1904

No sugar cane seedlings were propagated in Hawaii before 1904. In that year Charles F. Eckart, then Director of the Experiment Station of the Hawaiian Sugar Planters' Association, obtained 279 seedling plants. These germinated almost entirely from seed imported from the West Indies. None of these seedlings from the sowings of 1904 finally attained commercial significance.

1905

The Hawaiian Planters' Monthly of January 15, 1906, gave an editorial account of the work of 1905. In part it read:

The Experiment Station has this season attained remarkable results in the propagation of canes from seed. At the present time there are upwards of five thousand young plants, in various stages of growth, many of which are far enough advanced to plant out in the field. The results are all the more gratifying, because these plants all germinated from seed gathered at the Station from this season's tassels; whereas, in the experiments conducted last year, all of the plants that survived were from imported seed.

1906

The Annual Report of the Division of Agriculture and Chemistry of the Experiment Station for the year ending September 30, 1906, said:

During the tasseling period of 1905, the Division repeated its efforts of the previous season in the endeavor to produce seedlings from Hawaiian grown seed. Between the dates of December 6 and December 28, 1905, 5,608 seeds germinated in the propagation boxes, yielding 5,134 plants for setting out in the Experiment Station field.

Following the experience of the Division during the tasseling season of 1904, the success attending the germination of Hawaiian grown seeds in 1905 surpassed our expectations. This difference between the results of the two periods may be attributed to the following causes:

1. During the time the canes were in flower in 1904, high winds and excessively wet weather prevailed, the majority of the tassels being blown to pieces before the flowers were sufficiently matured to permit pollination and the formation of seeds. These conditions did not obtain to any serious extent in the winter of 1905.

2. In 1904 only a small number of canes other than Lahaina were in tassel simultaneously with the latter variety. The chances of cross-fertilization were therefore correspondingly small. In the winter of 1905 a large area of varieties, about forty in all, situated immediately to windward and bordering on a Lahaina field, were in flower.

*Originally published in the Honolulu Advertiser of September 16, 1923.

A very interesting observation with respect to the influence of adjacent varieties on the fertility of Lahaina seeds was permitted during the last season. In the Station fields there were two different areas under Lahaina cane, one being directly to leeward of the forty varieties mentioned, during the prevailing northeast trades, and the other to leeward of the same varieties only during the spasmodic northwesterly winds. From the former area under Lahaina 471 fertile seeds were obtained, and from the latter area only 60, notwithstanding that a greater number of tassels were taken from this particular locality than from the other

In addition to the seedlings enumerated above, 98 plants from unknown parents were planted in the field, making a total for the season's work of 5,232 seedling canes. . . .

1907

The Annual Report of the Station for the year 1907 said:

The large quantity of seedlings, 5,232 in number, which was originally set out has been reduced to 355, the total number representing those varieties which have shown up especially well.

The report of the Division of Agriculture and Chemistry said:

Following the first selection of seedlings from the sowings of December, 1905, it was found that a larger number than was expected would have to be retained for further trial, and to avoid the necessity of adding to the field area of the Experiment Station as would be required if they were to pass through the plat stage before being shipped to the plantations, the Division decided to modify the original plans with respect to their distribution. Accordingly, one cutting from each of at least fifteen seedlings was sent to each plantation in the Association to form the nuclei of cane nurseries. These consignments are to be followed by additional shipments of other varieties during the next planting season, and by 1909 it is expected that several hundred varieties will be growing in the nurseries of each plantation, and material will be at hand for subsequent careful tests into the relative suitability of the different varieties in their separate environments.

In April of 1907, a record was made of the appearance and general characteristics of each of the five thousand and more seedlings grown the previous year from the sowings of 1905. These canes bore the temporary numbers 280 to 5396, inclusive. Those canes which were to be reserved for further testing were given a permanent number; these ran from 1 to 333, omitting a few numbers which had previously been assigned to seedlings from the sowings of 1904. On April 16, 1907, the cane bearing the temporary number 1934 was marked "109" by Mr. Eckart, who had evidently given much personal attention to describing and selecting these canes, as the notes and figures designating the permanent numbers appear in his handwriting in a large record book which was used for this purpose.

The cane which thus became H 109 was a stool of eight stalks, a seedling of Lahaina. In general appearance it was "very fair"; in color, "rose". The sticks were "erect." The hopper resistance was "good"—internodes, "medium;" eyes, "medium;" rind, "hard;" rooting tendency, "very slight." A juice sample was obtained from two sticks; one of these was 13 feet 8 inches long, the other 6 feet 10 inches. The weight per foot of stick was 9.8 ounces. The juice resulting from a 54.5% extraction (juice on cane) had a brix of 19.4; sucrose, 17.9; purity, 92.3. The milling qualities were considered "good."

12

Hawaii No.	Parent.	Color.	Recum- bency.	Hopper Resistance.	Canes in Stool.	Internodes.
107	Indiana	yellow	moderate	good	4	medium
109	"	rose	none	"	8	"
110	"	yellow	"	"	15	"
111	"	"	moderate	"	9	"
112	"	"	"	v. fair	12	"
113	"	"	"	"	6	"
114	"	"	none	good	19	"
117	"	"	moderate	v. fair	10	"
118	"	"	"	"	12	"
119	"	"	"	"	15	"

30

393	"	"	"	v. fair	7	"
394	Yellow Bamboo	"	"	good	6	"
395	White Mexican	"	"	"	10	"
396	Yellow Bamboo	"	none	"	13	"
397	"	"	"	v. fair	9	"
398	Not known	"	moderate	good	7	"
399	White Mexican	yellowish, green	"	v. fair	10	r. long

A = Greatest growth from cuttings at age of 3 mos.

B = Next to A in growth from cuttings at 3 mos.

C = " " " " " " " "

T = Class of cane at time of selection of original stock for cut.

" " " " " " " "

" " " " " " " "

" " " " " " " "

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" " " " " " " "

Reproduction of portions of pages 12 and 30 of a copy of Circular 4 of the Experiment Station, H. S. P. A., marked by C. F. Eckart. Of more than five thousand seedling varieties inspected in 1907, H 109 was one of thirteen which was marked both with a rectangle to show that it was to be set out in plots in 1908, and with "A" to show that it was among those that had made the greatest growth from cuttings at the age of three months.

year, only twenty were marked with the letter "A" denoting, "greatest growth from the cane at the age of three months." Only thirty-seven were marked with a rectangle to show that they were "to be set out in plats in June, 1908, main field."

Of all the canes under observation in 1907, only thirteen were designated on both scores described above. These canes were: H 220, H 61, H 72, H 109, H 119, H 149, H 151, H 165, H 226, H 270, H 280, H 311 and H 385.

These records can leave no doubt but that H 109 was recognized as a promising cane in 1907.

Small lots of cuttings from a number of the seedlings were sent to the plantations in 1907. The plantations which received a cutting of H 109 in 1907 were the Waialua Agricultural Company and Hawaiian Agricultural Company. Separate record books were kept at the Station for the varieties under trial at each plantation. Notes from the Waialua Agricultural Company show that the H 109 sent there in 1907 was planted at an elevation of 1,100 feet. On April 25, 1908, the growth resulting from this planting was denoted as "good" by the Station representative. On October 27, 1908, E. G. Clarke marked the growth as "fair" and later, March 31, 1910, the ratoons were observed to be "poor" by J. H. Wale. Mr. Clarke and Mr. Wale were then agriculturist, and assistant agriculturist of the Experiment Station.

E. Faxon Bishop in his address as President of the Hawaiian Sugar Planters' Association, in discussing the work of the Experiment Station said, "Mr. Eckart's Hawaiian seedlings alone cover a great work, and it puts him in a class to be envied by all who are identified with scientific agriculture."

The H 109 shipped to the Hawaiian Agricultural Company in 1907 was planted at an elevation of 2,000 feet. An undated note says, "good growth, color, green." A subsequent note by Mr. Wale, on September 4, 1908, reads, "very good, 21 large sticks." The records show that the planting at 2,000 feet elevation was duplicated at 1,100 feet; and here again we find an undated note saying, "good growth, color green, healthy," and a note dated September 5, 1908, by Mr. Wale reading, "good." The cane planted at 1,100 feet and 2,000 feet elevations was cut for seed and planted on January 11, 1909, in field "Lower Goodale," about 1,300 feet elevation.

1908

The Hawaiian varieties had in 1908 been reduced to the number of 185. The Annual Report for that year records this fact, together with the statement that shipments to plantations had been made in 1908 and that further shipments were to be made in 1909. The unpublished records show that H 109 was sent in 1908 to Kihei Sugar Company, Niulii Mill and Plantation Company, and to the Union Mill Company.

The cane growth resulting from this shipment to Kihei was inspected on October 5, 1908, for a note reads: "Very good, better than Lahaina." This cane was replanted in Field A at 300 feet elevation. It is significant to note that of twenty-two varieties inspected at that time, only two of them are marked "Very good, better than Lahaina."

On May 18, 1909, the growth of this H 109 planting was again inspected and a note made reading: "Very good (second best)."

The shipment that went to the Union Mill Company in 1908 was planted, according to the memorandum, in "Field below cattle pen, mixed with 1907 cuttings." On September 22, 1908, Mr. Wale found the growth of this H 109 "very good," and on March 17, 1909, another note, probably that of Mr. Clarke, reads: "*Very good, (best).*"

The shipment of seedlings that included H 109 went to Niulii Mill and Plantation Company from the Station on June 16, 1908. These were planted at an elevation of about 650 feet and on September 23 Mr. Wale found the growth "*good.*" A later note, uninitialed, probably Clarke's, shows the growth of this H 109 "*very good, (one of the best).*"

1909

Mr. Eckart, in the Annual Report of the Experiment Station for 1909, listed the varieties that were showing up well on the preliminary trials on the plantations. The list of fifty-two canes on Hawaii included H 109. The Maui list named H 109 among nineteen varieties. Previous to 1909, the seedling H 109 had not been distributed to Kauai, and the only plantation on Oahu that had received the seedling that was destined to become the principal variety of the island was the Waialua Agricultural Company.

In 1909, however, the variety H 109 was sent to the following plantations:

Oahu—

Ewa Plantation Company
Kahuku Plantation Company

Maui—

Wailuku Sugar Company

Kauai—

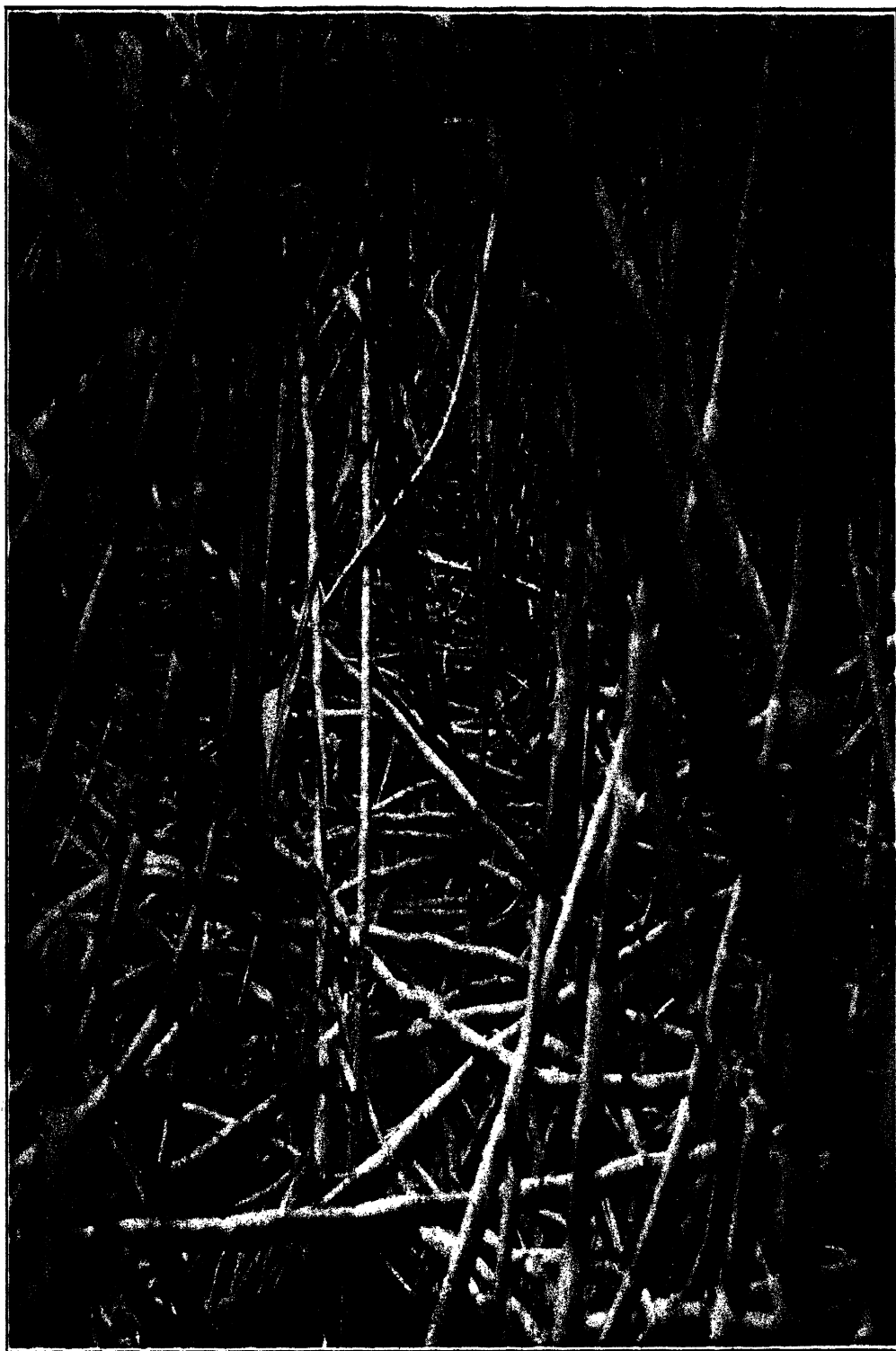
Kekaha Sugar Company, Ltd.
Lihue Plantation Company, Ltd.

Hawaii—

Halawa Plantation, Ltd.
Honomu Sugar Company
Laupahoehoe Sugar Company
Olaa Sugar Company, Ltd.
Union Mill Company

The cane resulting from the shipment that went to Ewa in 1909 was cut in 1910 and planted in Field 3A along with other seedlings and varieties that had been received from this Station in 1907 and 1908. These plantings in Field 3A were inspected on May 12, 1911, and a note by Wale reads, "very good." Only about six of the seedlings were so marked.

The Lihue planting of H 109 received in 1909 bears a note by Wale, April 11, 1910, "Good, equal to Yellow Caledonia."



In 1915, the Ewa Plantation Company reported over 1,071 acres of H 109 in their 1916 and 1917 crops. Oahu Sugar Company had 373 acres, and the Waialua Agricultural Company had 120 acres. A number of other plantations had begun to spread this cane. The early predictions in connection with the Hawaiian seedlings had come true. A cane of great commercial worth had been found. Photographed at the Experiment Station, H. S. P. A., Makiki Plots, 1924.)

The shipment sent to Kekaha was planted in March in the manager's yard at 15 feet elevation, and on April 7, 1910, Wale found the resulting growth "Good."

Dr. H. L. Lyon, in a pathological report dated October 24, 1910, reported that H 109 appeared to him to be one of the four best canes of the Hawaiian seedlings. H 20 had produced the thickest sticks, while H 109 had produced the longest.

1910

Twenty-three plantations were sent cuttings of H 109 from the Station in Honolulu in 1910. A list of these plantations by islands follows:

Oahu—

Honolulu Plantation Company
Oahu Sugar Company
Waimanalo Sugar Company
Waianae Company

Maui—

Hawaiian Commercial & Sugar Company
Maui Agricultural Company, Ltd.
Pioneer Mill Company

Kauai—

Kilauea Sugar Plantation Company
Koloa Sugar Company
Waimea Sugar Mill Company

Hawaii—

Hamakua Mill Company
Hawaii Mill Company
Hawi Mill & Plantation Company
Honokaa Sugar Company
Hutchinson Sugar Plantation Company
Kaiwiki Sugar Company
Kukaiau Sugar Company
Onomea Sugar Company
Paauhau Sugar Plantation Company
Pacific Sugar Mill
Pepeekeo Sugar Company
Puako Sugar Company
Waiakea Mill Company

1911

In the Annual Report for 1911, Mr. Eckart published the results of the first plat experiments, giving weights and analyses of thirty-one Hawaiian seedlings.

H 109 gave over a hundred tons of cane and ranked eighth in the test, outyielding Yellow Caledonia and Lahaina by liberal margins.

In connection with information to be given later concerning the development of H 109 at Ewa, it should be recorded here that this was one of the seedlings that had attracted the attention of the late George F. Renton as early as 1910, for on February 17, 1911, he wrote the following letter to Mr. Eckart:

I have your letter of the 16th inst., in which you notify me of shipment of five boxes of cuttings, namely, H 27 and H 99, from the Station to the Ewa Plantation Company. I am exceedingly obliged for these.

If you can spare them during the harvesting, I would also like to get some cuttings from the following varieties:

H 109, H 167, H 227, H 69, H 269, H 199, H 291, H 349.

I would also like to get any other varieties you care to send. I merely mentioned the above because I made a note of them when I visited the Experiment Station December 15th, last.

1912

It was in 1912 that data from preliminary tests on plantations began to confirm the earlier observations showing H 109 to be among the leading seedlings that were competing with the established varieties. The Annual Report of the Station read:

The work of testing and extending the seedling varieties has progressed appreciably during the year, and there are some plantations with considerable area devoted to the new varieties.

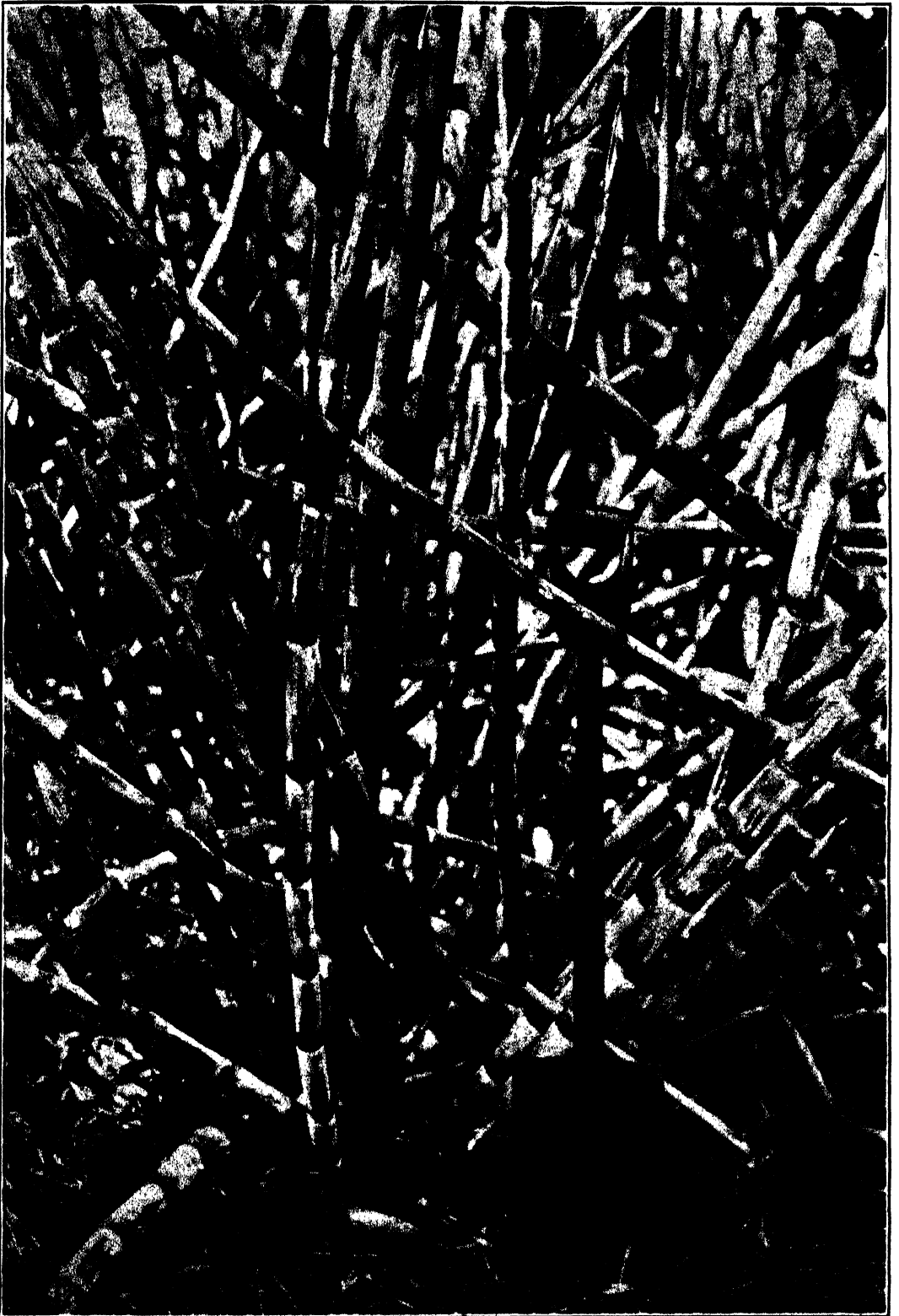
The results of preliminary tests have in several instances been reported, and the canes giving the more favorable yields in each case are indicated in the following tabulation:

Locality	More Promising Seedling Varieties			
Aiea	H 109	H 333	.....	.....
Waimanalo	H 27	H 109	.....	.....
Paia	H 27	.....	H 240	.....
Wailuku . . . . .	.....	H 333	D 1135	.....
Koloa . . . . .	.....	H 333	.....	H 338
Kilauea	H 27	H 109	H 335	.....
Onomea . . . . .	.....	.....	H 20	.....

These preliminary tests seem to place special emphasis upon H 27, H 109 and H 333.

At Waimanalo, H 109 had produced seven tons of sugar against five from Rose Bamboo. The Hawaiian Planters' Record of August, 1912, contained a brief article on seedlings at Aiea. The data published through the courtesy of James Gibb, showed H 109, in a single row test, to have yielded the remarkable result of 114.4 tons of cane and 20.58 tons of sugar per acre. H 109 growing between Lahaina and H 41 had evidently encroached upon its competitors.

In the short ratoon variety comparisons at the Station field, H 20, D 1135, H 99, H 333 and H 109 gave yields definitely better than Yellow Caledonia and Lahaina.



An exceptionally large stool of H 109 from forced cropping. Grown at the Experiment Station, H. S. P. A., Makiki Plots (1924).

1913

In the latter part of 1913 the writer compiled an acreage census of cane varieties.* There were thirteen Hawaiian seedlings included in a tabulation which is here reproduced. These were the foremost ones in point of area:

Variety	Acres Embraced in Crops of		
	1913	1914	1915
H 20.....	12	128	5
H 33.....	1	1	13
H 109.....	...	26	62
H 146.....	20	39	63
H 181.....	...	1	10
H 197.....	...	20	18
H 202.....	1	1	10
H 227.....	...	12	119
H 291.....	...	25	15
H 333.....	...	4	60
H 335.....	8	...	18
H 338.....	...	33	30
Striped Mexican †	165	146	283

There were in all twenty-six Hawaiian seedlings which had been extended to areas of one acre or more. The report said:

To these twenty-six Hawaiian seedlings the H. S. P. A. plantations are now devoting 822 acres for the 1914 and 1915 crops. By far the greater portion of this is on the island of Oahu, which contributes 699 acres or 85% of the whole amount. Hawaii furnishes 103 acres and Kauai 18 acres, while Maui reports but 2 acres.

Looking more closely into these figures we find that Ewa Plantation has a greater area in Hawaiian seedlings than all the rest of the Territory put together, or 467 acres against 355 acres to express the fact in figures. Of the remaining 355 acres the Oahu Sugar Co. claims over half, so that these two plantations have 650 acres against 172 reported from the other plantations of the Association.

The acreage census of 1913 showed no areas as large as one acre of H 109 on Hawaii or Kauai. The late George F. Renton then had at Ewa 25 acres of H 109 in his 1914 crop, and another 25 acres in the 1915 crop. Of H 20 there were 12 acres in the 1913 crop, and 128 in the 1914. Of H 227 there were 12 in the 1914 and 28 in the 1915.

These figures indicate that Mr. Renton, with less than four years' experience with H 109 on the plantation, had already discerned its commercial possibilities.

It should be noted also that at Waipahu, E. K. Bull had 12 acres of H 109 in the 1915 crop. At Waialua, W. W. Goodale had one acre in the 1914 crop and 8 in the 1915.

On Maui, H. B. Penhallow reported one acre of H 109 in the 1915 crop.

Fifteen plantations, in all, were experimenting with H 109, but only those named above had extended the variety to an acre or more.

* Circular 19, Agricultural and Chemical Series, "A Report on the Question of Cane Varieties."

† Including Louisiana Striped, which is supposed to be the same variety.

The *Record* for June, 1913, had an article, "Seedlings at Ewa," giving returns from seedlings "from the standpoint of extent of area, the most important results that have yet been published on these canes." A half acre of H 109 had yielded 8.88 tons of sugar and five other Hawaiian varieties had done even better.

1914

Experiments harvested at Waipio in 1914 showed H 109 among the seedlings which outyielded Lahaina and Yellow Caledonia by wide margins.

The *Record* for June, 1914, reported that a field of 25.2 acres at Ewa planted August, 1912, harvested April, 1914, had yielded 8.66 tons of sugar per acre against 5.16 from an inset of Lahaina. In the same issue, figures published through the kindness of Mr. Renton showed H 109 to be second in a list of twelve Hawaiian seedlings, the juice of H 109 being richer than any of the rest.

1915

In 1915, the Ewa Plantation Company reported over 1,071 acres of H 109 in their 1916 and 1917 crops. Oahu Sugar Company had 373 acres, and the Waialua Agricultural Company had 120 acres. A number of other plantations had begun to spread this cane.

The early predictions in connection with the Hawaiian seedlings had come true. A cane of great commercial worth had been found.

There were, however, but 13 acres as yet on Maui, 10 at the Maui Agricultural Company and 3 at Wailuku.

On Kauai, the Hawaiian Sugar Company reported 20 acres and McBryde Sugar Company 107.

1916 to 1922.

The rapid expansion of H 109 taking the place of Lahaina as that variety rapidly declined, is best shown in statistical form, giving the area of two crops at a time so as to include the cane area as a whole:

	H 109	Lahaina
1913-1914	26	80,905
1915-1916	597	72,459
1917-1918	3,928	65,474
1919-1920	11,889	53,679
1921-1922	30,578	32,617
1923-1924	52,487	13,486

In 1922, the largest area in H 109 at any one plantation was 9,403 acres at the Hawaiian Commercial & Sugar Company. Ewa reported 7,328 acres. Oahu

Sugar Company had 6,577 acres, and Waialua Agricultural Company, 2,683. Other plantations with extremely large areas were:

Hawi Mill & Plantation Company.....	882 acres
Hawaiian Sugar Company.....	2,335 "
McBryde Sugar Company.....	2,611 "
Maui Agricultural Company.....	4,360 "
Pioneer Mill Company.....	3,528 "
Honolulu Plantation Company.....	3,085 "
Kahuku Plantation Company.....	1,145 "
Waianae Company	1,509 "
Waimanalo Sugar Company.....	857 "

As this is written, September 10, 1923, the area of H 109 in all probability exceeds 60,000 acres by a wide margin.*

Notes on Insect Pests in Samoa

By O. H. SWEZEY.

While in Samoa four weeks during September, 1923, every opportunity was taken to make observations on insect pests of economic importance there.

Apparently the most destructive pests are those of the coconut and banana, and they appear to be such as have comparatively recently arrived there from elsewhere, probably from other islands of the South Pacific.

The worst pest on sugar cane is the borer, the same kind that we have in Hawaii. As cane is grown in Samoa only for thatching the native houses, the damage done by the borer is not taken so seriously as if it were a commercial crop.

INSECTS OF SUGAR CANE.

Perkinsiella vitiensis Kirk. This leafhopper was usually to be found in patches of sugar cane, though not abundant enough to be injurious. In fact the insects themselves were rather so scarce as to be difficult to find, but their presence was known by the discoloration of the midrib of the leaves where eggs had been deposited. Very few eggs were found anywhere, and I failed to find any that were parasitized. However, a few of the little round exit holes were found which indicate where the egg-parasite *Ootetrastichus* had issued. This was very likely the same species (*Ootetrastichus beatus* Perkins) that occurs in Fiji. The adult parasite oviposits in eggs of the leafhopper. In developing, the parasite larva consumes the leafhopper egg in which it has hatched, it then eats the other 2 to 7 eggs of the same cluster of leafhopper eggs. Having obtained its growth the larva transforms to the pupa and adult in a small cavity in the leaf tissue, and gnaws the tiny round exit hole to make its escape when fully matured. This egg parasite was introduced from Fiji to Hawaii in 1905 where it rendered valuable assistance in checking the cane leafhopper (*Perkinsiella saccharicida*

* The census of November, 1923, showed that there were 66,141 acres under cultivation.

Kirk.) occurring there. A single specimen of the egg-parasite was collected in a cane patch on the island of Tau of the Nanua group, which proves to be the Fiji species mentioned.

Rhabdocnemis obscura (Boisd.). The cane borer was generally present and quite injurious. In some places worse than others, sometimes scarce and hard to find in cane patches. Often it was easier to find in coconut trees, where its larvae were in the bases of old leafstalks, usually the stubs where leaves had been cut off.

A colony of the New Guinea Tachinid fly parasitic on the larvae of this borer was sent to the Naval Station, Pago Pago, in 1918. I learned that the flies had been liberated in a cane patch at a Samoan village on Pago Pago harbor. As I was not able to find any of the parasites anywhere that I looked, it must have failed to become established. If it had succeeded in establishing, it could have spread quite generally by this time. Other colonies of this parasite have recently been sent in further attempts to establish it there.

Elytroteinus subtruncatus (Fairm.). A beetle which has been known as the ginger weevil, or else a very closely related species was found in cane along with the cane borer in a cane patch on the side of the mountain above Fagasa village. Quite a number of larvae were found, mostly in broken off canes lying on the ground and already somewhat bored by larvae of *Rhabdocnemis obscura*. A few pupae were found which were saved till they matured to the adult beetles.

Longicorn beetle. A few larvae of a Longicorn beetle were found in dead canes on the ground in the same cane patch at Fagasa. These were not reared, so their identity is not known. They were probably some dead-wood borer, and not a particular cane insect, probably only attacking dead canes.

Melanitis leda Linn. On two occasions the larva of this butterfly was found feeding on cane leaves. One of them was reared, thus proving its identity. It is a green caterpillar, probably a special cane insect, though not numerous enough to be considered a pest. I do not know if it feeds on other plants than cane. It occurs in Fiji, and quite widely distributed in the South Pacific.

Cosmopteryx dulcivora Meyr. The larva of some small species of moth was found boring in the midribs of cane leaves, fairly common, but not specially injurious. I failed to rear any adults, but it is likely to be the species here given which occurs in Fiji with similar habits.

Mealybugs: *Pseudococcus sacchari* and *P. calceolariae*. Both of these species of mealybugs were found, the former more common than the latter. Both feed on the cane stalks at the nodes, inside of the leaf sheaths. No parasites were found associated with these, nor ladybeetles feeding on them.

Aleyrodes bergii (Sign.). In several different places, colonies of an Aleyrodid were found on cane. They were usually on the underside of the leaf and near the base, and in quite dense clusters of a few hundred insects occupying a space of 2 to 3 inches along the leaf. They were not numerous enough to cause any significant injury. This species also occurs in Fiji.

Diaspine scale. In the cane patch at Fagasa, a few stalks of cane were found having a scale on them near the joints. Not numerous enough for injury. The species has not been determined.

COCONUT INSECTS.

Oryctes rhinoceros Linn. The rhinoceros beetle seems to be considered the most important of all insects that affect the coconut in Samoa. The injury is done by the large adult beetles feeding and burrowing in the growing crown of the coconut tree, where they may cause such injury as to result in the death of the tree, or they may only mutilate the undeveloped leaves so that they cannot become fully developed and of proper service to the tree, or it may be that the undeveloped fruiting clusters are so much injured as to prevent the bearing of nuts. The appearance of the newer mutilated leaves serves to indicate when and where the beetle is prevalent. The larvae or grubs are not injurious but feed in dead and rotting stumps and logs.

Searching out these grubs and destroying them is the chief control measure being practiced. It seems to be quite effective when persistently and thoroughly carried out. One day per week is designated as "beetle day", on which the natives are required to make special search for these grubs. Many thousands of them are thus found by chopping up old logs and stumps. Their eggs are also found in this way, and a few of the beetles themselves, all of which are destroyed. Much benefit is derived in this way, but the work would be greatly facilitated if the coconut groves were kept free of the native jungle of brush and vines that has such a tendency of rapidly choking up the space beneath the coconut trees. On account of this undergrowth there is great difficulty in finding the breeding places of the beetles and many will escape detection, and thus enough grubs go through to maturity to keep the beetle continuously going.

Rhabdocnemis obscura (Boisd.). The sugar cane borer is found quite commonly in coconut trees. The beetles may be found behind the bases of the leaves where they can readily hide amongst the fibrous matter, but the grubs were usually found in the bases of the leafstalks, and mostly in those that had been cut off leaving a stub remaining on the tree. These cut off ends provided a place where the adult beetles could conveniently lay their eggs, which accounts for the grubs being more often found in such positions. On account of this habit of feeding in these places, this weevil is not of important injury to the coconut trees.

Diocalandra taitensis (Guer.). The Tahiti coconut weevil was found quite abundantly in places. It is much smaller than the sugar cane borer. Its larvae feed in the edges of the lower part of the leaf stalk, and as it is the older leaves that are most often attacked, they are not significantly injurious to the trees. They, too, are likely to be more abundant in stubs of cut-off leaves.

Promecotheca reichii Baly. This is a Hispid beetle whose larvae are leaf-miners in the leaflets of coconut. The egg is laid on the surface of the leaf, and the young larva on hatching bores into the leaf and feeds on the inner green part of the leaf, producing a dead spot on the leaf where the green matter has been eaten away. The larva transforms to a pupa and eventually to the adult beetle within the mine in the leaf. This was not observed to be abundant enough to be particularly injurious.

Leaf Caterpillar. Everywhere the coconut leaves showed evidences of the feeding of some insect which ate off the surface in small spots, leaving one epidermis of the leaf and giving the appearance of numerous small dead spots on the leaflets. No insects were found actually doing this eating, but it was considered as being the work of caterpillars of some small moth which was out of season at the time I was there. I thought at the time that the appearance of the leaves was different from that caused by the little moth, *Lecruana iridescens*, which injures coconut leaves so badly in Fiji.

Graeffea minor Br. Stick insects were found feeding somewhat on coconut leaves in a few places. In feeding they consume the whole substance of the leaf, so that the leaflets have ragged edges, or may even be eaten down to the midrib. A larger species, *Graeffea cocophaga* (Newp.), is also said to feed on coconut leaves, but I failed to find any of these. The damage by these insects did not seem to amount to much.

Chrysomphalus rossi (Mask.). This scale insect was found frequently on coconuts, occurring on or beneath the scales at the base of the nuts; also on other parts of the tree. It did not seem to be particularly injurious.

Scholastes bimaculatus Hendel. This fly appears to be attached to the coconut, but perhaps not as a pest, as it apparently breeds in decaying nuts. The fly is usually seen on fallen nuts lying under the trees. What I considered their eggs were found by thousands beneath the scales at the base of immature coconuts lying on the ground, that had fallen off accidentally by the wind, or had been partially eaten by the flying fox, which damages the young nuts on the trees a good deal. I also found very numerous small pink maggots feeding in the decaying husk of similar nuts lying on the ground, which I took to be the maggots of this fly. However, these conclusions are not to be given too much importance. Further observations are necessary to fully learn the life history and habits of the fly and its exact relations to coconuts.

Termites. A species of termite that is very abundant in the forests of Samoa, builds large, black, rough-surfaced nests on the trunks of trees from one to ten feet or more from the ground. They feed in the trunks, also build narrow covered runs about on the surface of the tree trunk, often extending to a considerable elevation in the tree. Beneath these runs the termites feed on the bark.

Coconut trunks frequently bear these termite nests, a favorite position for the nest being at one of the numerous notches that have been cut into the trunks by the natives to facilitate climbing the trees for the nuts. Besides providing a place for the entrance of termites to the trunk, these notches also present opportunities for decay to set in which diminishes the productivity of the tree and shortens its life. This phase of it is probably more detrimental than the injury by the termites, and it seems to me that this practice of notching the trees should be discouraged.

BANANA PESTS.

Cosmopolites sordidus (Germ.) The banana weevil was found in a number of places. Perhaps it has only lately become established and not yet generally spread. The larva of this beetle is a fat, white, legless grub which bores in the

corm and base of banana stems. The adult is a black snout-beetle and may be found in the same places and beneath the dried leaf bases at the base of banana stems. This pest is very destructive to bananas where it occurs in Fiji, Queensland, Java and probably most of the groups of islands between there and Samoa. Where numerous in the base of banana stems these are weakened and may easily fall over, or the plant prevented from normal growth and fruiting, and the young suckers may be entirely killed. This pest has become very serious in Fiji and it is very difficult to devise satisfactory methods of control. It is likely to increase to that condition in Samoa.

Nacoleia octasema Meyrick. The banana scab moth is generally prevalent. The caterpillars of this moth feed among the flowers and the green bananas on the bunch. Where they feed on the surface of the young growing bananas it does not always prevent their growing to normal size, but the surface where eaten assumes a scabby appearance which is detrimental to the sale of the fruit. The bunches, too, are unattractive where littered up with the black frass from the caterpillars.

This pest occurs from Java to Queensland, Solomon Islands, and to Fiji and Samoa, and no doubt it occurs at all intervening islands. I think that it has not been previously reported in Samoa, and may be of somewhat recent introduction there. In Java, dusting with pyrethrum powder is said to be effective in controlling the pest. The pyrethrum is mixed 1 part to 3 parts of sifted wood ashes or lime, and dusted into the opening flower cluster or among the small growing bananas by means of a syringe-like duster.

PAPAIA FRUIT-FLY.

Chaetodacus xanthodes (Broun). This fruit-fly was reared from immature fruits of papaia at Amauli towards the east end of Tutuila. I did not find it generally attacking papaias, but it is not confined to papaia, as it has been reared from guavas and granadillas. Fruit-fly maggots were found in aligator pear, and in several kinds of native fruits in the forest, but none of these were reared. so we do not know if they were this species or other species of fruit-flies.

TARO INSECTS.

Chaerocampa celerio (Linn.). The larvae of this medium sized hawkmoth were occasionally found feeding on the leaves of taro, not numerous enough to be considered injurious, however. It occurs from India to Java, Borneo, Australia, and Fiji. The large green caterpillars with a horn at the tail end may be readily picked off and killed when noticed.

Megamelus proserpina Kirk. This is a small leafhopper found on the underside of the leaves, and often quite numerous though not especially injurious. It occurs in Fiji, Java, the Philippines and probably intervening regions.

Several other kinds of leafhoppers were collected on taro leaves, but were not considered as particularly attached to taro the same as *M. proserpina* is.

Aphidid, an undetermined plant louse, was also found on the leaves of taro, but not causing serious infestations.

INSECTS OF CUCURBITS.

Glyphodes indica Saund. The larvae of this widely spread leafroller moth were occasionally found on cucumber vines, but in no case were they numerous enough to be considered a pest.

Aulocophora fabricii ? A leaf-beetle probably of this species was quite abundant on squash and pumpkin vines.

As nearly all of the insects above mentioned do not now occur in the Hawaiian Islands, and as some of them are serious pests where they are, we may consider ourselves fortunate if they can be kept from reaching our islands.

Of the 10 insects on sugar cane mentioned only 3 are at present infesting cane in Hawaii: the borer and the two mealybugs. Some of the others, although not serious pests on cane in Samoa might possibly become pests if they reached Hawaii, the same as the leafhopper from Australia became such a bad pest, whereas it was not a bad one in Australia.

The most of the coconut insects are not present in Hawaii either. The leaf-roller that we do have, however, causes the leaves to look more dilapidated than they do in Samoa with several kinds of insects feeding on them. Our one pest on coconut leaves is too much, we surely do not want any more.

The banana borer and the banana scab moth would ruin the banana industry in Hawaii if they should gain access here, and there is no telling what the papaia fruit-fly might do here, as it has been reported bred from pineapples from Fiji, though not fully substantiated.

As Samoa is the closest tropical neighbor from which steamers are coming regularly, it is the most likely place from which some of the already widely distributed tropical insect pests could accidentally reach Hawaii, and makes it urgent that a constant lookout is maintained to prevent as long as possible any more such pests arriving here.

The Identification of Cane Varieties*

By TWIGG SMITH.

For the past few months I have been studying and making drawings of the characteristics of a great many of our canes with the object of testing the constancy of certain morphological characters used by Dr. J. Jeswiet of Java, as an additional means of classification and identification of sugar canes.

I have found that his system can be applied here and that the characters he writes of are constant.

This system of Dr. Jeswiet's is a very valuable addition to the usual agricultural description by which cane is generally recognized.

* Presented at the meeting of the Association of Hawaiian Sugar Technologists, October, 1923.

Not only is it possible to recognize the standard varieties, but it is possible to make a description of seedlings so that wherever they are grown they too may be recognized.

Later, it will be possible to tell the parentage of seedlings by these additional characteristics.

The system may be likened to the Bertillon system.

In Java where they have specialized in seedling cultivation for years, it became absolutely necessary to have some definite means of identification other than the outward appearance of the cane growing in the field. We in Hawaii are now confronted with the same problem. We have our standard varieties pretty well known by appearance, and it is possible for many men expert in cane culture to pass through a field and pick out each variety, but it would be extremely difficult to do so under different climatic conditions or with seedlings. The seedlings in Java were mostly secured by the caging or bagging method, and were therefore of known parentage, but as it is not possible to get even two seedlings that are exactly alike, even from the same tassel, it was becoming increasingly difficult to recognize the seedlings once they had left the experiment station. It was necessary to find some morphological characters that under all conditions would remain constant or nearly so. It is well known that the usual means by which cane is recognized is faulty, as the appearance of cane is so subject to variation under different climatic conditions.

I do not mean that the usual method of recognition is valueless by any means, but that as some of the principal points on which recognition of variety is based are valueless under different growth conditions, it should be used with reservations and checked by means of Dr. Jeswiet's system.

First let me go over the usual method of identification. On mature cane we look for stalk, roots, and leaves. On the stalk for length, position and number or quantity per stool. Every stalk has a number of nodes and internodes. The internodes themselves are distinguished by color, waxlayer, shape, circumference, length or position, by the presence or absence of the eye groove, cork cracks, and growth cracks, growth ring, root ring, number of root eyes, and color of the rind fibre.

The sheath of the leaf is attached at the joint or node, and when it is removed the eye is seen, just above the leafsheath scar.

Now most of the points mentioned are subject to variation with a change of environment or difference in fertilization or water supply.

Stalk length and diameter are enormously influenced by climatic conditions or change of soil. On poor soil long cane may grow short, and thick cane thin, and the individual internodes likewise are affected.

Color is very changeable; exposed stalks, and those on the outside row, are often of a different color than the inside ones. In H 109 for instance, the color may run from yellow green to dark purple.

However, the color impression of full grown cane is fairly constant and is of great use, but it must be used with reservation and never can be used solely as a basis for cane classification. The color change may become permanent, however, by bud variation or vegetative mutation. The other parts used in

description are all more or less subject to variation, perhaps the most reliable are: First, fine cracks, called cork cracks by some writers, running the length of the internode, in the ground tissue, which later may dry up and may change to black lines. Second, growth cracks; a great many canes show these and they appear to be constant. Third, shape and location of the root ring or band, not its color, and the number of rows of root eyes seen in the root ring. In the interior of the cane joint, the rind fibres may be brown or colorless. There are many varieties of cane that have brown rind fibres, and it is a very constant characteristic for the variety.

Those items and some other characteristics which the agriculturist or cane grower becomes familiar with have made up the usual method of identification and as long as clearly differing varieties were being dealt with it was not difficult for one familiar with cane to differentiate. But when it came to seedlings of very mixed parentage, as is the case where field pollination is carried on, or even when dealing with thousands of seedlings of known parentage, it becomes exceedingly difficult to authoritatively separate them and the result is always open to doubt.

Here is where Dr. Jeswiet started. He found that the usual method of identification was at fault, and that many canes of similar appearance but entirely different sucrose content were being called by the same names. He found many canes of the same variety were being called different names in different localities. He then searched for and found certain morphological characters that would remain constant despite climatic or agricultural changes. He states that "In the structure and hairing of the normal eyes we have an exceptionally reliable and good indication of variety as well as in the structure and hairing of the leaf sheath, its juncture with the blade, the root zone, etc." He prepared plans of the types of eyes and marked the hairgroups as they were found, and at present there are 31 positions where hairgroups may be found on the eye, and 21 on the sheath, its juncture with the leaf, and the blade.

We understand by eye the cane bud, of which there is always one (except in rare cases when the eye is missing or when there may be double or triple eyes), growing in the root ring above the leaf sheath attachment.

They alternate to the right and left of the stalk, generally straight above one another and are absent in upper joints of the flowering stalks.

The eye is enveloped by a first or outer scale and grows from the stalk. On the outside of the eye the scale is in two halves, the upper one passing over the lower to a greater or lesser extent. I have found some eyes with no break in the outer scale. This outer scale may or may not have wings which also may vary much in size and in their manner of attachment. Again the wing may have ears attached to its free edge as I found to be the case with a cane imported by the Experiment Station from Java a short time ago.

There are two main shapes of eyes, round, and oblong or longitudinal. With round eyes the wings are found attached above center, and with oblong below. The basal parts of attachment are called wing corners. The round eyes have a more or less central, the oblong eyes an apical germ pore. By germ pore is meant the germination point through which the young shoot emerges, either by pushing

aside the flaps of the enveloping scale or splitting it. Since the scale nerves come together at the germ pore, the round eyes have a radially shaped nervature, whereas the oblong pointed eyes have more or less straight nerves.

Between these two shapes of eyes many transitions occur. It may happen that under unfavorable conditions a variety with round eyes may develop oblong or pointed eyes. With the changes in shape the veining changes and compact hair groups may become long stretched ones or vice versa. Notwithstanding this variation in shape, veining and germ pore are reliable characteristics in the variety description when sufficient material is available. The eye is not always growing close to the leaf sheath scar, it may be in one variety and in another it may be much higher up on the stalk. Also it may be tightly pressed against the stalk, or standing out from it.

All eyes are more or less haired.

These hairs are either white, and range from short bristles to long soft hairs, or brown black and then always short. The latter class is considered primitive and is in many cases covered or pushed aside by the longer white hairs.

The kind of hairs is very different for the different varieties and they are remarkably constant in their grouping.

It is clear that both the presence as well as the absence of the different groups are considered in the description.

Of course, the appearance and the size of the groups as well as the length of the hairs themselves are subject to variation, which may be rather large for certain groups, but in a comparatively small number of sticks taken at random a sufficient number of eyes can be found which correspond to the typical hairing.

The leaf sheath, the blade and their juncture, carry groups of hairs that Dr. Jeswiet also has numbered and shown on his plans.

The ligule is a small strip of tissue at the juncture of the sheath and blade. It may or may not be haired. The auricles which are an appendix to the leaf sheath may be large or small. Some varieties have no auricle, some only one. They also have characteristic hair groups, one of which (group 70) assisted in identifying a cane in the Java importation, P. O. J. 36. The* joint triangles are the triangular zones at the juncture of blade and sheath above the ligule. They differ very much for different botanical varieties in shape and hairing. At times they are almost totally absent. They are generally different in color to the leaf and with their hairing help in variety division. The leaf sheath and blade have groups of hair which are characteristic for group and variety divisions.

I do not intend to create the impression that it is only necessary to examine a few eyes or a leaf or two of any cane in order to be able to identify it. There are a few varieties that so far have been easy to place and some that are hard.

It will be necessary to carefully gather and file the deviations and variations from standard types of eyes, etc., for each variety and gradually build up a reference library, so that recognition will be made easier.

* The joint triangles are called articulation triangles by Dr. Jeswiet of Java, basal triangulares by Wm. F. L. Fawcett of the Tucuman Experiment Station, and have been called dewlaps by Dr. Lyon of this Station.

It is not so hard to distinguish between the older canes, such as Badila, Striped Mexican, Caledonia, Lahaina, H 109, Uba, etc. The difficulty lies in separating and recognizing parentage of seedlings. Until we have examined many seedlings of known parentage it will be a difficult problem, as there is no method of arriving at how much of the hairing of eyes and leaves are transmittible characters. However, if we are able to make accurate descriptions of seedlings and continue to file them away it will be of immense value.

Some of the characteristics of parent canes are easily distinguished in their progeny. For instance, I am reasonably sure that many of the seedlings of Yellow and of Striped Tip now growing at the Manoa Substation have D 1135 for their other parent. Again, the known hand pollinated crosses of D 1135 and Uba propagated in 1923 and now growing at the Makiki Station show characters of both parents. Also a few stools of seedlings in one plot at the Station were marked on the blue print with a certain number denoting crosses between Striped Mexican with the other variety unknown. They were so much like Striped Mexican in appearance that I examined them carefully and found that they were Striped Mexican. Later I found that the seedlings had died and had been replaced by Striped Mexican seed pieces, but the blue print had not been changed.

H 109 possesses many different shaped eyes but more of a certain definite type and nearly always with serrated or notched edges. With all the differences in shape the hairing is remarkably constant and yet in growth habit and appearance this variety differs greatly with its location.

Another instance of the practical value of this system of identification was in checking the recent importation of Java seedlings.

The Experiment Station some months ago received cuttings of four varieties from Washington, D. C., which originated in Java and have been grown successfully in many parts of the world.

They were originally produced from known parents by the caging or bagging method, crosses between Cheribon and Chunnee and Striped Preanger and Chunnee. Cuttings were sent to Washington, grown there, and now cuttings from that growth were sent to the Experiment Station here. They are now growing in the Pathological Plot. Dr. Jeswiet described three of these canes in the *Archief* of the Sugar Industry of Java and published drawings of the eyes.

I have examined these canes and find that they check with Dr. Jeswiet's description. This examination was made at 7 months of age, saving a wait of many months till the cane could be tested in other ways. We are reasonably sure now that the canes are of the varieties they were supposed to be and they can be safely distributed as such to be tried out under our different growth conditions.

The plans showing the hairgroups as used by Dr. Jeswiet in this system of identification were published in the *Record* of October, 1923, beginning on page 326.

We have just received from Dr. Jeswiet new drawings showing the disposition of all groups up to date and now wish to correct errata and add new groups to the article in the October *Record*.

Group 28. (Should read:)

A group of short hairs growing above and pointing into the germ pore and surrounding it at the upper half.

This group is present in EK 28, Bandjermasin hitam, and other canes.

Group 27. (Omitted before.)

A small group of rather short white hairs somewhat beneath the top of the overlapping scale.

In some canes this top is abnormally developed and then the group is very distinct.

The positions of groups 52 and 58 should be reversed, descriptions remaining the same.

Group 69. (Should read:)

One or more rows of isolated soft hairs on both sides of the midrib on the basal part of the leafsheath, on the outside.

Very rare, found in Loethers, Java, and some of its seedlings.

Some Photographs of Primitive Methods of Sugar Production

The accompanying photographs show some of the primitive methods of sugar production in the Philippine Islands, but slightly changed, if at all, from the original Chinese methods of cane growing, extraction and boiling. To those in the highly specialized branches of sugar production in Hawaii there may be a



justifiable feeling of satisfaction in the progress made from such methods of sugar manufacture of early days.

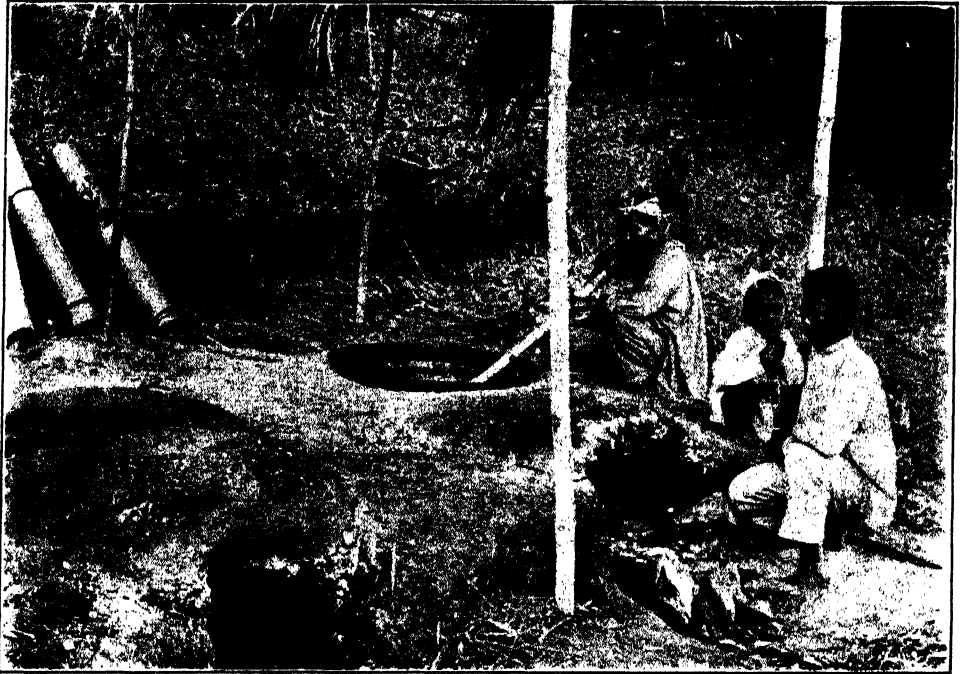
The first photograph shows the plowing of fields by the heavy, slow-moving carabao, or water buffalo. These animals have few or no sweat pores and there-



fore can be worked only 3 to 4 hours a day in the usual hot weather in cane fields. The plows shown in the photograph are of wood and turn the soil over to a depth of possibly four inches except under unusual conditions. Such wooden



plows used in the Orient have but one handle as compared with the two-handled plows of western countries.



The second photograph shows the furrowing by the water buffalo, and planting. The women doing the planting in this case received from forty to sixty centavos per day without food or lodging, equivalent to twenty to thirty U. S. cents per day.



The third photograph shows the milling equipment in detail. The power is furnished by a carabao and in this case there are two vertical rollers of stone fitted to wooden shafts; the gears in the photograph are of wood. There are many muscovado mills which have advanced to the use of small, steam-driven, steel rollers.

The fourth photograph shows the boiling house. At the left of the picture are three bamboo tubes which are used to carry water or to take the juice from the mill to the kettles.

The fifth photograph shows the boiling house of a much larger and improved muscovado mill. Of interest in this photograph are the dippers made of empty gasoline tins on bamboo poles and the bamboo pipes to transport the juices from one part of the house to another.

These muscovado mills, although they can still be seen, are very rapidly disappearing in the Philippines now, their place being taken by factories of the Honolulu Iron Works, such as that of the Hawaiian-Philippine Company, with daily capacities of as high as 2,500 tons of cane, and with production in one case of 35,000 tons of centrifugal sugar each season. Similarly wooden plows are seldom seen in use now. The photographs are from the collection of the Philippine Bureau of Science.

H. A. L.

Cane Deterioration

A Summary.

By J. A. VERRET.

We present herewith a summary of the data we have bearing on the loss of sugar in the cane which takes place in the interval of time between cutting or burning and milling.

This loss takes place in two ways. There is a deterioration of juices whereby sugar is destroyed, and there is an indirect loss due to loss of cane weight caused by evaporation. In order to determine the total loss it is necessary to not only determine the juice deterioration but also to know the loss in weight of the cane.

WORK IN FOREIGN COUNTRIES.

It appears that but little work along these lines has been done in other countries, as a search in our library shows but few references to this subject.

The few references found are given briefly as follows:

Noel Deerr reports the following as the mean of seven experiments conducted by himself on the evaporation of cane when exposed in heaps of about fifty pounds:

Days cut	1 day	2 days	3 days	4 days	5 days
Per cent loss in weight.	2.19	4.03	5.49	7.37	8.57

He does not report weather conditions during the tests, nor does he state where they were conducted. Our losses in weight were of about the same order as those reported by Deerr.

Weinberg gives the following data, showing the loss of available sugar in cut cane:*

Days Cut	0	1	2	3	4
Available sugar per 100 A. S. in original sample....	100	97.3	92.0	78.6	67.9
Total Loss of A. S.	0	2.7	8.0	21.4	32.1
Daily Loss of A. S.	0	2.7	5.3	13.4	10.7

J. A. Hall, Jr., from experiments conducted in Argentina, with a number of different varieties of cane, pointed out that they did not deteriorate at the same rate, as the following selected list shows:

PURITIES OF THE JUICE.

Variety	Fresh	6 to 8 days	9 to 11 days
Louisiana Striped	87.9	82.7	72.1
Java 36	84.5	58.2	51.4
Java 234	87.3	70.5	60.8
Kavengire	83.8	41.1	32.6

Comparatively cold weather prevailed during these tests, the temperature varying from a little above 32° F. at night to 86° F. in the day, with no rain.

Muller von Czernicky, working in Java, found that the purity of the juices of cane stored for five days indoors dropped from 94 to 82, and when the cane was left one day in the field and then stored five days indoors, that the drop was from 94.6 to 74.2 purity.

In a recent publication, "The Cultivation of Sugar Cane in Java," by R. A. Quintus, the author says:

Cut cane should be removed the same day, since if it remains behind on the reaped field, exposed to the sun, the cane sustains a great loss of available sugar. The great retrogression in point of "available sugar" percentage in canes that remain exposed to the sun for one or more days appears clearly from the figures below:

Number of days exposure to the sun	Brix	Quotient Purity	Glucose per cent	Loss of weight per cent	Available sugar per cent
0	21.3	94.3	0.2	0.0	16.2
1	22.1	94.6	0.3	2.1	16.0
2	22.4	86.4	1.0	3.3	13.5
3	22.8	79.7	1.9	4.3	11.6
4	22.8	77.1	2.3	5.4	10.8
5	23.8	74.1	?	6.6	9.9

Much available sugar is therefore lost by inversion, while the weight of the cane is diminished by drying.

* We do not understand the mathematics, but this is as reported by the author.

H. Pellet, working in Egypt, found that the factors influencing deterioration were (1) the size of the cane; (2) the density of heap; (3) the temperature of the atmosphere; and (4) the force of the wind.

He found that small cane lost more weight, and that the denser the pile the less the loss. Windy days increased the loss. Quiet, moist days decreased it.

LOCAL WORK ON DETERIORATION.

The first work done on this subject in these Islands of which we have record was done by Mr. P. Messchaert, Chemist at Oahu Sugar Company in 1910.

He took cane from Field 30, a car at a time. The cane was stripped and weighed. It was then placed upright against an iron railing and trash piled about it and burned. The amount of trash used was that from the area from which the cane was taken.

He summarizes the results of three tests as follows:

PERCENTAGE AVAILABLE SUGAR LEFT IN GREEN CANE AND IN BURNT CANE FOR TWELVE DAYS AFTER CUTTING.

Table	Green Cane				Burnt Cane			
	Test 1	Test 2	Test 3	Average available sugar	Test 1	Test 2	Test 3	Average available sugar
Loss in Weight					4.75	3.25	7.90	5.30
First day.....	100	100	100	100	90.7	94.9	95.4	93.7
Second day.....	97.1	101.5	101.4	100	85.4	95.0	93.8	91.4
Third day.....	93.6	98.7	101.4	97.9	86.0	94.4	92.9	91.1
Fourth day.....	96.6	97.4	98.1	97.4	84.3	83.9	88.0	90.9
Fifth day.....	97.6	87.5	93.6	92.9	82.7	95.6	88.4	88.9
Sixth day.....	94.7	86.6	88.9	90.1	80.4	86.4	83.6	83.1
Seventh day....	89.9	86.5	84.3	86.9	78.2	88.3	78.6	81.7
Eighth day.....	88.5	88.5	84.5	87.2	77.5	81.1	71.7	76.8
Ninth day.....	87.1	90.0	77.9	85.0	81.6	86.1	64.6	77.4
Tenth day.....	83.1	87.7	78.6	83.1	77.1	77.3	62.9	75.8
Eleventh day...	87.6	85.5	75.5	82.9	77.0	69.5	58.0	68.2
Twelfth day....	85.5	84.1	70.6	80.1	68.3	74.3	49.4	64.0

It is interesting to note here that Messchaert found a loss of 36% from burned cane in twelve days or 3% a day. The Station, ten years later in a much more elaborate test at Ewa found a loss of 2.97% per day for about the same period of time.

Apparently Messchaert's report did not attract much attention for it was not until 1919 that the matter of cane deterioration was again taken up in a systematic way, when Verret and McAllep started some work in Honolulu and planned experiments to be conducted on the plantations.

A total of about 30 experiments was conducted during 1919 and 1920.

The results obtained by Verret and McAllep are given as follows:

The data presented were obtained under Honolulu conditions with 50-stalk bundles and embrace three widely planted varieties. As shown in the following tabulations, one may note, in the first place, the loss in weight independently of the deterioration in

quality; secondly, an estimation of the tons of cane required to make a ton of sugar for each two-day interval. Finally the cumulative effect of both of these significant losses is shown by combining the two and expressing the percentage of loss of available sugar with each succeeding two-day period.

LOSS IN WEIGHT.

	D 1135	Lahaina	H 109
Fresh	0	0	0
2 days old.	4.5%	4.6%	4.0%
4 days old.	8.1%	8.7%	7.4%
6 days old.	9.7%	12.5%	9.9%
8 days old.	12.0%	15.4%	13.0%

DECLINE IN QUALITY AS SHOWN BY QUALITY RATIOS.

(Tons of Cane per Ton of Sugar.)

Fresh	7.30	7.08	7.34
2 days old.	7.63	7.15	7.73
4 days old.	9.08	8.45	8.27
6 days old.	10.41	10.56	8.64
8 days old.	11.04	11.33	10.47

LOSS OF AVAILABLE SUGAR AS FOUND BY COMBINING THE WEIGHT LOSSES AND THE DECLINE IN QUALITY.

	D 1135	Lahaina	H 109	Average of the Three Varieties
Fresh	0	0	0	0
2 days old.	8.8%	5.7%	2.8%	5.8%
4 days old.	27.0%	24.7%	12.2%	21.3%
6 days old.	34.7%	41.4%	18.0%	31.4%
8 days old.	42.0%	47.4%	34.9%	41.4%

In April, 1919, a cane fire occurred on Hutchinson Sugar Plantation Company. It took fifteen days to grind this burned cane. C. Brewer & Company supplied us with data showing the juice deterioration during this period. Taking account of the estimated loss in cane weights the following losses took place:

No. of Days After Fire	% Sugar Loss
5	11.7
6	14.9
7	15.9
8	20.4
9	26.6
10	35.8
11	41.0
12	47.9
13	50.6
15	57.2

Here the loss was 2.35% per day for the first five days. But from the seventh day on the losses increased rapidly and amounted to 57% in fifteen days.

In the same year a deterioration test was conducted at the Hawaiian Sugar Company with bundles of cane and resulted as follows:

Days after burning	% Loss in weight	% Loss in Sugar
1	3.94	6.0
2	6.56	10.4
3	....	....
4	11.29	29.5
5	15.11	38.2
6	18.22	34.4
7	21.80	32.2

On account of the small samples used and the lack of repetitions the results are not concordant, but indicate a possible loss of about 4% a day.

In July and August, 1919, Paauhau Sugar Plantation Company conducted two tests. The summarized data follow:

LOSS IN WEIGHT IN PER CENT.

Days after cutting	1	2	3	4	5	6	7	8	9
First test	1.9	3.3	4.7	6.2	5.0	5.9	7.9	10.1	11.4
Second test	2.7	3.9	4.0	4.6	6.7	5.7	7.4	7.1	8.7
	—	—	—	—	—	—	—	—	—
Average	2.3	3.6	4.3	5.4	5.8	5.8	7.6	8.6	10.0

LOSS OF SUGAR—IN PER CENT ORIGINAL SUGAR.

Days after cutting	1	2	3	4	5	6	7	8	9	10
First test.....	5.6	19.2	20.6	26.8	33.9	32.6	29.9	30.9	....
Second test....	2.4	3.2	6.8	10.5	10.8	15.7	29.0	7.8*	21.5	30.5
	—	—	—	—	—	—	—	—	—	—
Average	2.4	4.4	13.0	15.5	18.8	24.8	30.8	29.9	26.2	30.5

Small samples were used and the results are not concordant from day to day. But it is interesting to note that the indicated total sugar loss amounted to 30.5% in ten days. Here again we find this loss of about 3% per day for the first ten days.

In 1920, in order to obtain more accurate figures upon which to base estimate of insurance payments in several extensive cane fires a large experiment was conducted at Ewa.

A very uniform section of Field 3A, of slightly over three acres, was selected. This was divided into 48 plots, each plot being large enough to give several car loads of cane, thereby making good samples. There were 12 repetitions of each treatment.

For the purpose of this report a summary only of the results will be given. These were as follows:

* Discarded.

Treatment	Time since Burning	Yield per Acre		% Loss in Weight of Cane	% Loss in Sugar	Brix	Crusher Juice		
		Cane	Sugar				Pol.	Pur.	Q. R.
Block 1	Unburned	86.4*	10.54	.....	.....	18.9	16.32	86.3	8.18
" 2†	0 day	87.2	10.57	.....	.....	18.9	16.23	85.9	8.25
" 3‡	0 day	87.3	10.41	.....	.....	18.6	15.95	85.8	8.37
Block 1	Unburned	92.9*	11.09	.....	.....	18.5	15.96	86.3	8.36
" 2	5th day	81.5	8.96	6.57	15.23	18.6	15.09	81.1	9.13
" 3	5th day	73.9	8.93	15.30	14.22	20.2	16.68	82.6	8.18
Block 1	Unburned	88.4*	10.55	.....	.....	18.3	15.95	87.1	8.34
" 2	10th day	77.3	7.48	11.39	29.23	18.6	14.00	75.3	10.30
" 3	10th day	67.7	7.26	22.45	30.26	21.0	15.69	74.7	9.23
Block 1	Unburned	84.8*	10.09	.....	.....	18.1	15.81	87.4	8.39
" 2	15th day	69.0	5.11	20.89	51.66	18.1	11.75	64.9	13.64
" 3	15th day	61.8	5.33	29.18	48.80	22.1	14.01	63.4	11.60

The above table may be condensed as follows:

LOSSES DUE TO BURNING.

Time since burning	Tons Cane per Acre	Crushed Juice				Sugar per Acre	% Loss in Weight of Cane	% Loss in Sugar
		Brix	Pol.	Pur.	Q. R.			
0 days	87.20	18.9	16.23	85.9	8.25	10.57	.....	.....
5 "	81.45	18.6	15.09	81.1	9.15	8.96	6.57	15.23
10 "	77.25	18.6	14.00	75.3	10.30	7.48	11.39	29.23
15 "	68.97	18.1	11.75	64.9	13.64	5.11	20.29	51.66

The cane was H 109, first ratoons. The cane was mature, but had been recently irrigated. The soil was still somewhat moist. No rain fell during the period of the test. It was very warm with bright sunshine. The cane was burned on July 26.

The losses shown in the above tables would apply particularly to late spring and summer conditions. Earlier in the year when the weather is not so warm and the atmosphere contains more moisture it is possible that the losses would be somewhat less, especially losses in cane weight.

During 1920, twenty-three tests were conducted on four plantations, these were Paauhau, Onomea, Kilauea and Hawi. These tests were conducted under the auspices of the Hawaiian Chemists' Association, Mr. Raymond Elliott was chairman of the committee.

In summarizing the results Mr. Elliott reported in part as follows:

The cane loses weight from the time it is cut until it is ground, although the conditions vary. When the weather is hot and with a breeze the loss in weight is at the maximum, whereas, when the atmosphere is saturated with moisture, the loss is lessened.

The difference between burned and unburned cane is distinctly seen at Paauhau and Kilauea.

* 5% off for trash.

† Block 2 Cane burned and allowed to stand until harvested.

‡ Block 3 Cane burned and cut at once, and allowed to lie on field until harvested.

The burned cane deteriorates faster than unburned cane, practically under the same condition, with rainfall very slight in both places, for the first three days.

Taking the average after cutting for burned cane, the loss for the first day is 3.8%, representing five tests from three districts, variety Yellow Caledonia. For unburned cane, the loss for the first day is 2.52%, representing six tests from four districts, variety Yellow Caledonia.

For the second and third days the losses for burned cane are 8.88% and 9.67% as against unburned, which are 5.67% and 6.49% respectively.

The ratios in favor of not burning are: first day, 1.51; second day, 1.57; and the third day, 1.49.

Following are Tables 1 and 2, showing the averages for burned and unburned cane:

TABLE NO. 1—BURNED CANE. VARIETY: YELLOW CALEDONIA.
% LOSS IN SUGAR.

Plantation	No. of Tests	No. of Days after Cutting							
		1	2	3	4	5	6	7	8
Paaauhau	1	.46	8.16	18.77	16.93	13.87	18.09	18.04	19.03
Kilauea	1	*2.30	.....	* 1.8	2.6	9.6	.....	.....	.....
Kilauea	3	5.76	18.10	18.51	32.02	.....	.....	.....	.....
Kilauea	4	8.49	8.93	7.96	7.29	12.62	.....	17.20	.....
Hawi	1	6.6	.3	4.9	3.3	* 1.5	19.9	* 3.0	28.6
Average	10	3.80	8.88	9.67	12.43	8.63	19.00	16.12	23.82

TABLE NO. 2—UNBURNED CANE. VARIETY: YELLOW CALEDONIA.
% LOSS IN SUGAR.

Plantation	No. of Tests	No. of Days after Cutting							
		1	2	3	4	5	6	7	8
Paaauhau	3	2.22	3.70	5.25	12.58	19.18	21.27	28.05	30.02
Onomea	1	1.20	8.20	7.20	8.0	7.5	4.8	10.3	9.2
Onomea	2	2.10	2.90	* .5	8.8	3.1	3.8	1.5	3.2
Onomea	3	*4.00	.9	2.4	4.4	8.1	8.9	12.8	16.8
Kilauea	2	5.00	4.8	5.7	.....	12.6	.....	.....	.....
Hawi	2	8.6	13.5	18.9	37.6	36.1	48.2	34.2	43.6
Average	13	2.52	5.67	6.49	14.28	14.43	17.39	17.37	20.56

In these tests small bundles of cane only were used. It is impossible to handle small bundles of cane and obtain concordant results. But by averaging the results of all the tests we believe we obtain some information as to what to expect under general conditions.

The average losses are seen to be about 21 to 24% in eight days, or about 3% a day.

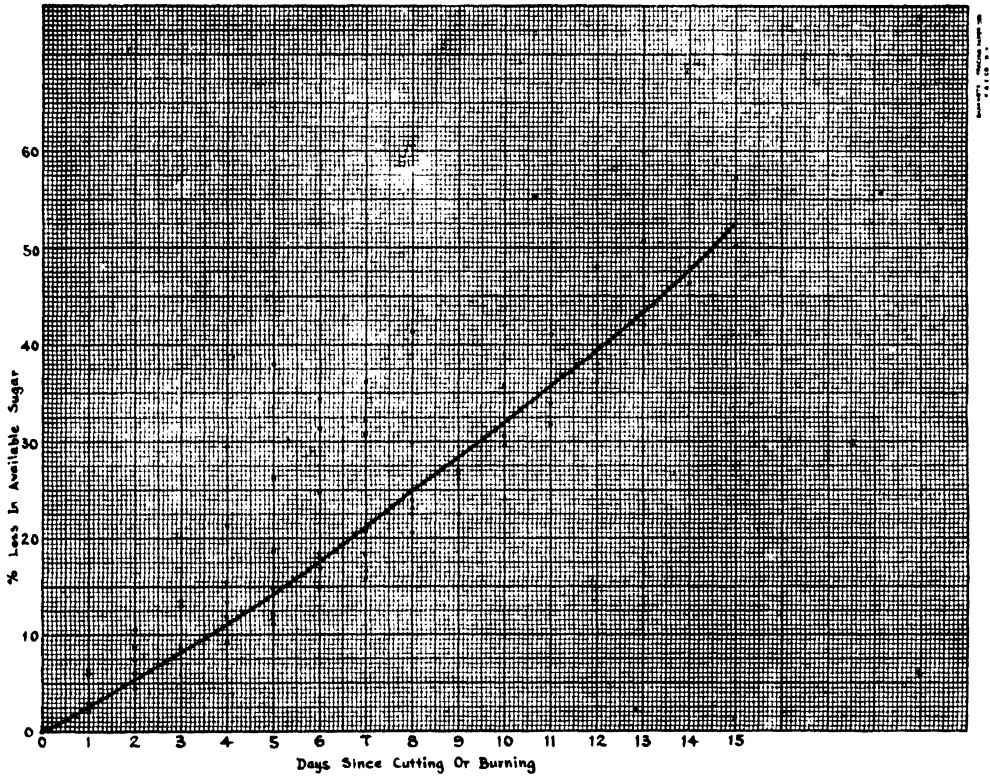
For the sake of convenience the summaries of the local tests are brought together in the following tabulation:

N. B. Onomea's cane assumed as unburned.

* Plus values.

Plantation	Conducted by	Tests	No. of _____ Days Old _____														
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
O. S. Co.....	P. Messchaert	3	2.3	8.6	8.9	9.1	11.1	16.9	18.3	23.2	22.6	24.2	31.8	36.0	....	....	....
Makiki Plot.....	Verret & McAllep..	3	...	5.8	13.5	21.3	26.3	31.4	36.4	41.4	....	....	....	....	....	....	....
Hutch. Sugar Plant....	V. Marcallino.....	1	...	....	....	....	11.7	14.9	15.9	20.4	26.6	35.8	41.0	47.9	50.6	....	57.2
H. S. Co.....	.....	1	6.0	10.4	....	29.5	38.2	34.4	32.2	....	....	....	....	....	....	....	....
Paauhau	Westly	2	2.4	4.4	13.0	15.5	18.8	24.8	30.8	29.9	26.2	30.5	....	....	....	....	....
Ewa Plantation Co.....	Verret	1	2.9	5.9	8.8	11.8	14.7	17.7	20.7	23.7	26.7	29.7	33.8	37.9	42.0	46.1	50.2
Hawn. Chemists' Assn..	Raymond Elliott,																
	Chairman	23	3.2	7.3	8.1	13.4	11.5	18.2	16.7	22.4	....	....	....	....	....	....	....

In the accompanying illustration the figures in the above table were plotted on coordinate paper and an attempt was made to draw a curve representing the average results obtained in these different tests.



It will be seen that this curve follows the Ewa results very closely.

It would therefore seem that, for average conditions, losses of the nature of those obtained in the Ewa test are to be expected from delays in milling after cutting or burning.

We hope to be able to do more work along these lines. Especially for the first two to four days after burning, as this is the period in which most burned cane is now handled.

Irrigation Investigations at Waimanalo

By G. R. STEWART.

PURPOSE OF THE EXPERIMENT.

The experiment was undertaken at the request of Messrs. C. Brewer & Company, to try and determine the economic limits in the use of irrigation water at Waimanalo. An additional water supply had been developed by the plantation and further work was contemplated. Information was therefore desired as to the maximum amount of irrigation water which the plantation could use and produce an adequate return in the production of additional sugar.

METHODS OF THE INVESTIGATION AND ORGANIZATION OF THE WORK.

The following plan was developed in conference with Mr. Chalmers, Manager, Waimanalo Sugar Company, and Mr. Agee, Director of the Station. Large plots of about an acre or more were to be chosen in several typical fields. These plots were to receive complete irrigation from the time of starting the experiment up to the time of ripening the cane before harvesting. These extra irrigated areas were to be compared to similar plots in the same fields, which received the ordinary plantation treatment.

Three such experiments were started. One experiment was laid out in Field 8, and another in Field 22, in cane which was about a year old. A third experiment was located in Field 15 where young plant cane was just up. In addition four observation plots were chosen in Fields 1, 3, 12 and 14, where the cane was to receive only the usual plantation treatment. This was for the purpose of studying the effect of variation in the growing conditions, in different portions of the plantation.

The following work was carried out on the three comparison experiments:

1. Measurements were made of the irrigation water applied to the extra irrigated plots and the crop cane. V-notched weirs of standard type were employed in this work.

2. Determinations were made of the moisture content of the soil in the extra irrigated plots before and after irrigation. In the ordinary crop cane moisture determinations were made between irrigation periods, in addition, to follow the moisture changes during these longer periods of time. The method of making the determinations is briefly as follows: Four to six or more duplicate borings were made in each plot at every period of sampling; the borings being spaced 30 to 60 feet apart. The borings were carried to a depth of six feet and samples from the boring of each individual foot were analyzed and the results for each foot then averaged.

3. Weekly measurements were made of the growth of the cane in all plots, irrigated and unirrigated. The system followed was that used by the agriculturists of this Station. In each plot in the areas to receive extra irrigation, and in similar locations in the crop cane, four to six typical stools of cane were chosen. The number of shoots and stalks were counted and tags attached to each stalk for future identification. Two average stalks in each stool were chosen and a copper wire ring was fixed near the base of the stalk, and measurement was made from the node near this ring to the base of the last visible dewlap. Later in the work another copper ring was placed higher up on the stem to facilitate the work of measurement.

4. The above observations were to be correlated with the regular mean temperature readings which are made by the plantation weather station.

RESULTS.

The work was started by the members of the Chemical Department, but was soon taken over by Mr. William Weinrich for Waimanalo Sugar Company. We have continued to cooperate in the measurement of the growth and in making the moisture determinations. In briefly summarizing the results from the commencement of the work on June 26 to November 30, I desire to emphasize the fact that this is only a preliminary report. It appeared desirable to bring together the data so far obtained, so that the results might be available to those especially interested in this problem.

WATER MEASUREMENT RESULTS.

The results of the measurement of the irrigation water in all three experiments are given in Table I. At the beginning of our work the soils in all three fields were very dry. We therefore directed the irrigators to put on what they considered a full irrigation with one man's water, each week. As soon as we were able to start accurate measurements it was found that the amounts were radically different in each case.

In Field 8 the average irrigation was 4.5 to 5.0 acre inches. We were soon able to extend the period between irrigations in this field, from one to two weeks. The first few irrigations had to be made without measuring weirs, so the figure in such cases is the average of the later applications and is enclosed in parenthesis.

In Field 22 the irrigators were applying about 3.3 acre inches at an irrigation, so we continued the weekly period of irrigation throughout the experiment.

TABLE I.

SUMMARY OF IRRIGATION APPLIED TO EXTRA IRRIGATED AND CROP CANE.

Field 8			Field 22			Field 15, Plant Cane		
Date of Irrigation.....	Extra Irrigation Cane Acre Inches.....	Crop Cane Acre Inches.....	Date of Irrigation.....	Extra Irrigation Cane..	Crop Cane.....	Date of Irrigation.....	Extra Irrigation Cane..	1 Month Irrigation Period.....
June 30...	(4.83)	....	July 1...	(3.30)	....	July 5...	(1.51)	....
July 20...	(4.83)	(4.29)	July 8...	(3.30)	....	July 14...	(1.51)	....
July 28...	(4.83)	....	July 14...	(3.30)	....	July 21...	(1.05)	....
Aug. 10...	(4.83)	(4.29)	July 21...	(3.30)	....	July 28...	(2.21)	....
Aug. 24...	(2.76)	....	Aug. 4...	3.98	4.84	Aug. 4...	1.50	....
Sept. 7...	5.42	5.04	Aug. 18...	3.22	....	Aug. 18...	1.40	....
Sept. 21...	4.82	....	Aug. 25...	4.31	....	Aug. 25...	1.53	2.00
Oct. 4...	5.33	....	Sept. 1...	3.45	....	Sept. 1...	1.45	1.89
Oct. 18...	5.91	....	Sept. 8...	3.47	6.80	Sept. 8...	1.53	....
Nov. 2...	4.81	3.55	Sept. 15...	2.76	....	Sept. 15...	1.23	....
Nov. 29...	4.76	....	Sept. 23...	2.97	....	Sept. 30...	1.81	2.56
			Sept. 30...	3.97	4.98	Oct. 6...	1.74	....
			Oct. 6...	3.10	....	Oct. 13...	1.76	....
			Oct. 13...	3.16	....	Oct. 20...	1.90	....
			Oct. 20...	3.33	....	Oct. 27...	1.02	2.04
			Nov. 3...	2.46	2.76	Nov. 3...	1.42	2.20
			Nov. 10...	2.73	....	Nov. 10...	2.07	....
	53.13	17.17		56.11	19.38		25.64	4.09
	8.08	8.08		8.08	8.08		8.08	8.08
	61.21	25.25		64.19	27.46		33.72	12.17

One Month Irrigation experiment not started till August, so Irrigation is not totaled.

It will be seen that the total amounts applied to both fields in the extra irrigated and crop cane are practically the same. The extra irrigated area received practically three times the amount of water given to the crop cane.

In Field 15 the average irrigation in young cane was found to be 1.5 to 2.0 acre inches. We continued to apply this amount each week and found this kept the soil close to the optimum moisture content. In this field, Mr. Weinrich found it advisable to install another comparison after the work was under way. This was to apply irrigation regularly once each month. The results of these applications are not totaled as it would not be comparable with the extra irrigated and crop treatments. Here it is seen that the extra irrigated cane received approximately six times as much irrigation as the crop cane.

Owing to the acute water shortage during the past season, which was intensified by the necessity of putting in so much plant cane, the irrigation rounds were

rather irregular in the ordinary plantations fields. We were therefore not able to get complete irrigation data on the applications to the crop cane experiments in Fields 1, 3, 12 and 14. Our work on these four plots has been especially concerned with soil mixture and growth studies.

MOISTURE DETERMINATIONS.

For simplicity of observation the moisture data is presented in the form of graphs, in which the moisture of the extra irrigated plots is compared with the moisture in the soil of the crop cane area. The moisture results are all expressed as per cent of dry weight of soil, as is usual in irrigation water studies. On this basis the optimum moisture percentage in the Waimanalo soils was found to range from 45 to 55%, though fair growth may take place if the content occasionally drops to 40%. A moisture content continuously below 40%, is certain to retard the growth of the crop.

Chart I gives the moisture results for Field 8. The curves show that the moisture in the extra irrigated plot was kept well up towards the optimum. The soil of the crop cane plot was notably lower at many periods. This was especially true in the top two feet of soil, but some differences prevailed at the lower levels.

Chart II gives the moisture results for Field 22, which show the same differences between the extra irrigated and crop cane.

Chart III gives the results for Field 15. Here the differences are especially striking in the first and second feet of soil, where this young cane was largely feeding.

Chart IV gives the results for three of the drier fields, Nos. 1, 12 and 14. Here the range of moisture lay far below the optimum content, even down into the fifth and sixth foot of soil. The curves for these lower depths are discontinuous, owing to the presence of rocks in some sample holes.

MEASUREMENTS OF GROWTH.

Our first plan was to estimate growth in two ways, by the elongation of the sticks, and by a count of the development and size of new shoots formed after full irrigation was applied. These two estimations were carried out but we observed toward the close of the work covered in this report, that the elongation of cane in the drier fields after a rain or irrigation did not express the growth correctly. A considerable elongation frequently took place, but the size of the stick was greatly inferior to sticks which were making about the same growth with regular water. Mr. Weinrich therefore carried out a very painstaking measurement of the volume of the sticks in two typical rows of cane in Field 15. One of these was in the extra irrigated and the other in the regular crop cane. A comparison of the results brings out several interesting differences. A brief summary of results of our elongation studies is given in Table II. These tables give the average length of the measured sticks of cane at the beginning of the experiment and on November 30. The increase is given in feet and the gain due to irrigation is calculated.

CHART I
MOISTURE DETERMINATIONS
FIELD 8.

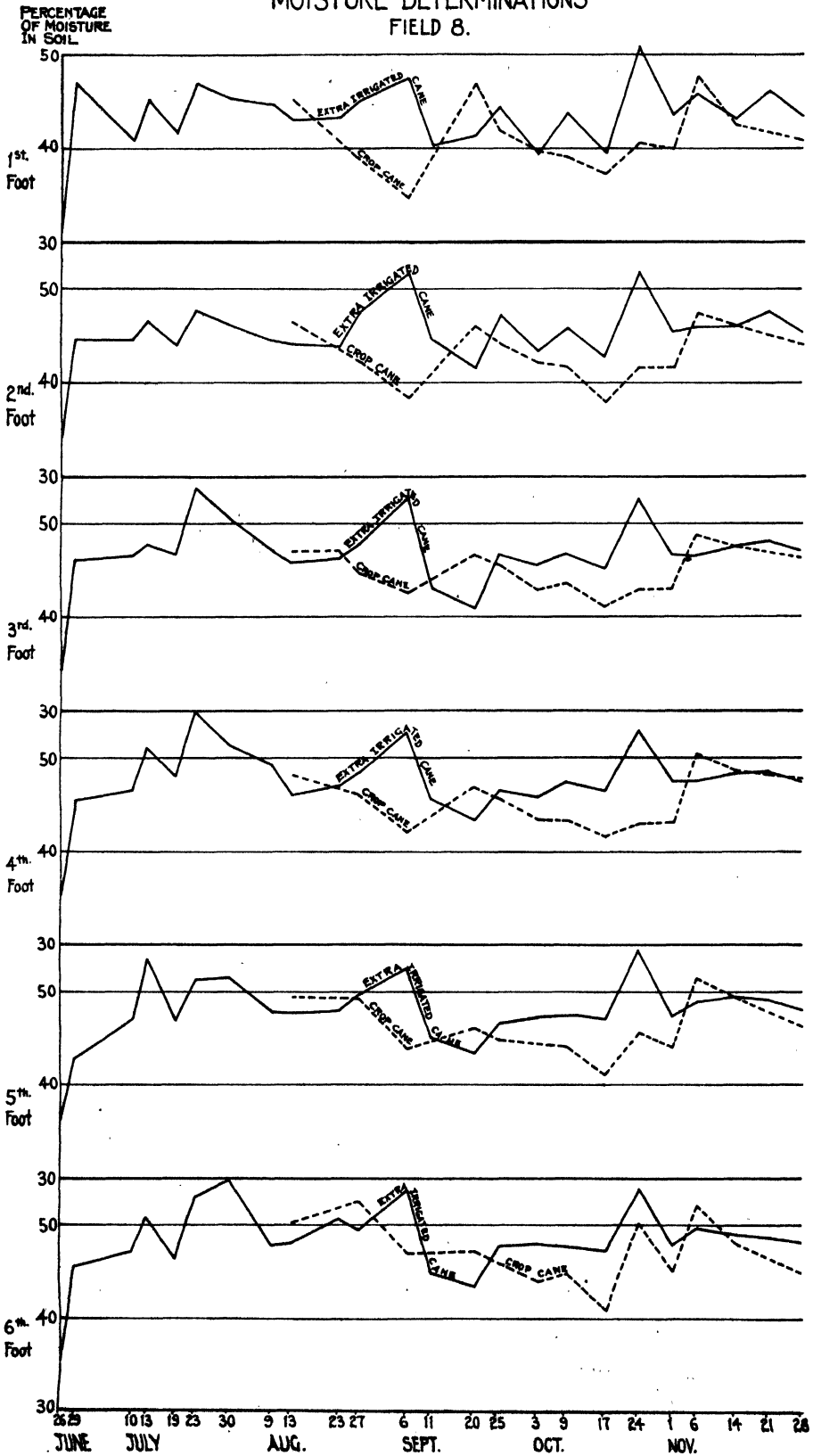


CHART II MOISTURE DETERMINATIONS FIELD 22.

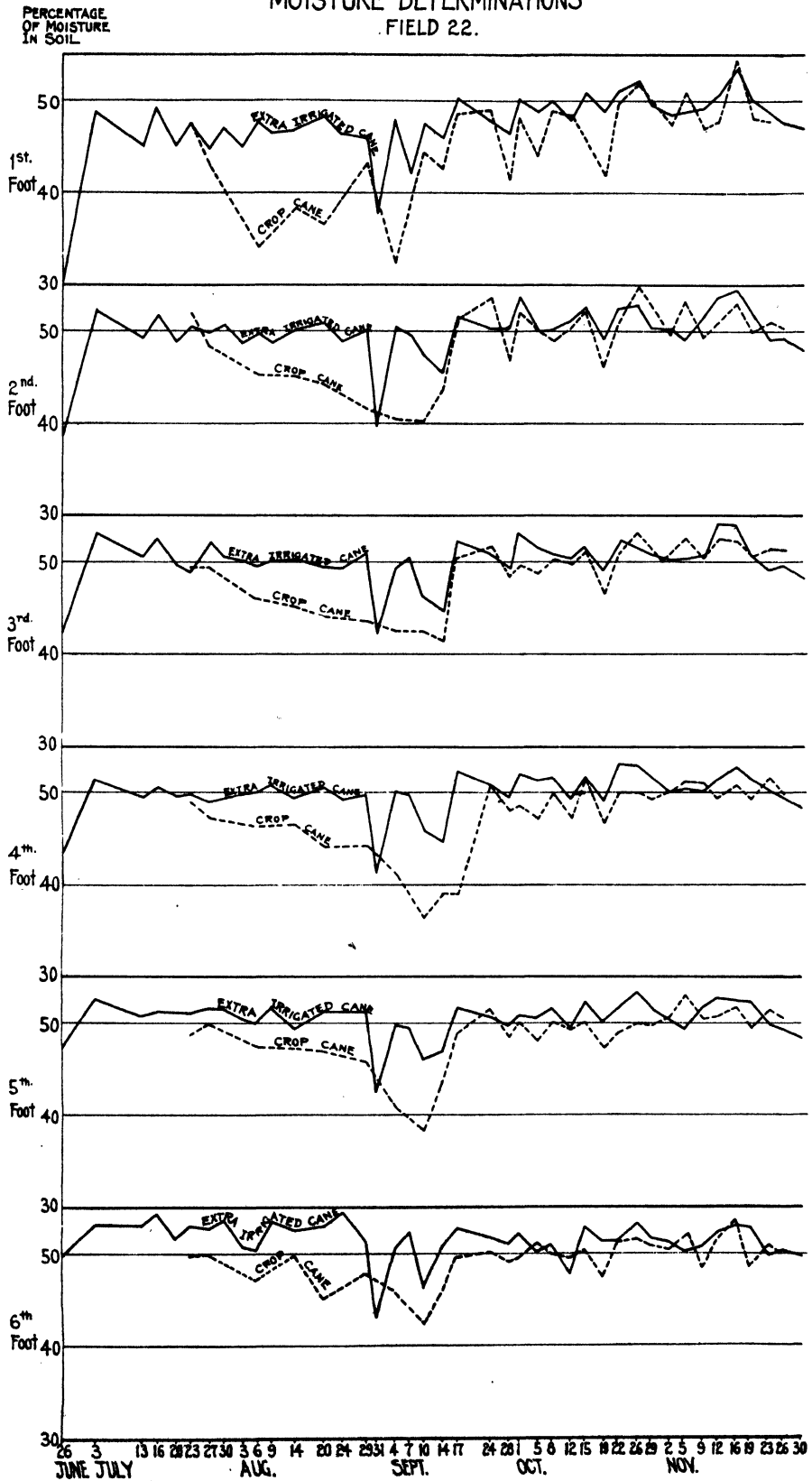
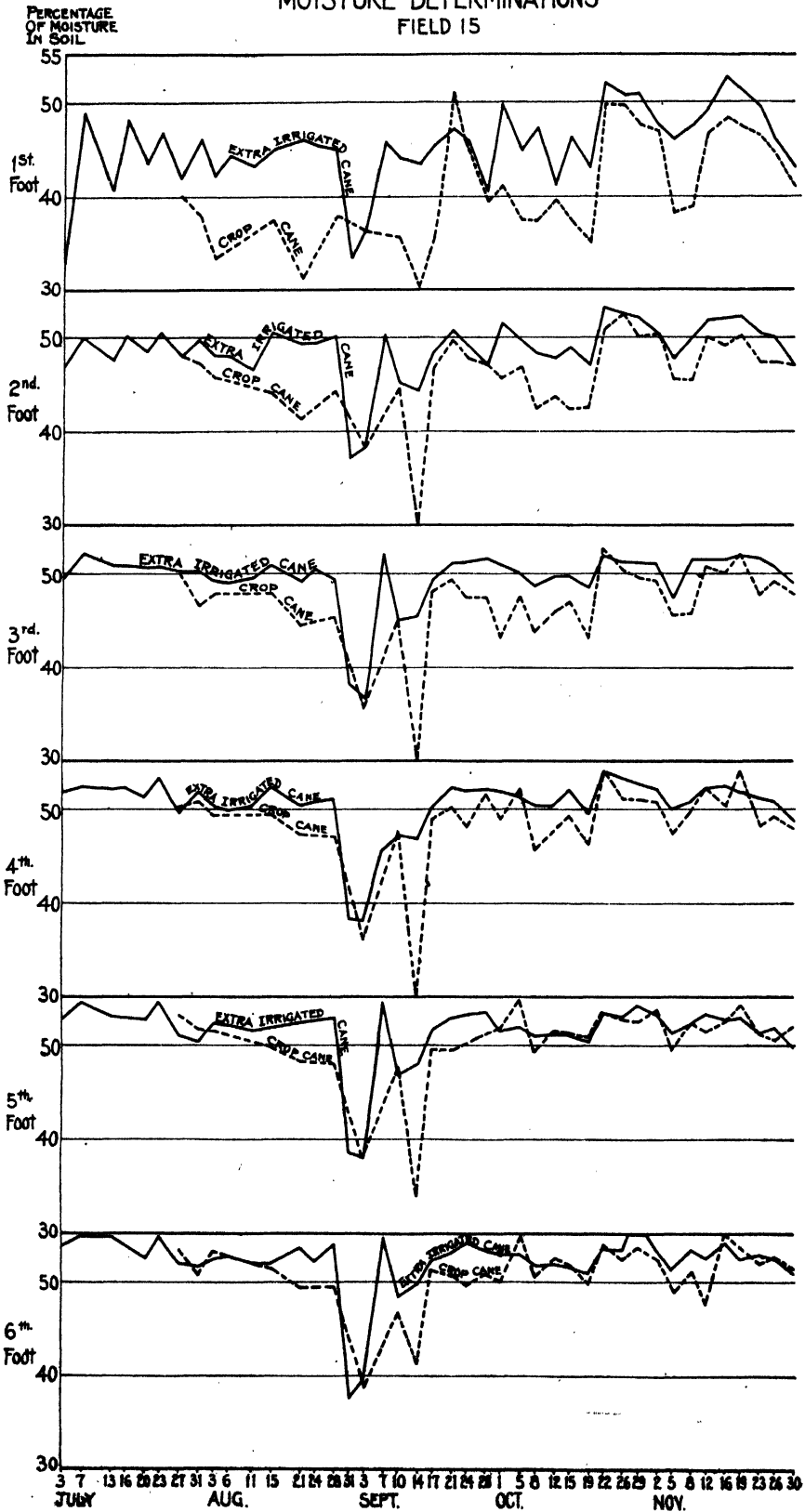


CHART III MOISTURE DETERMINATIONS FIELD 15



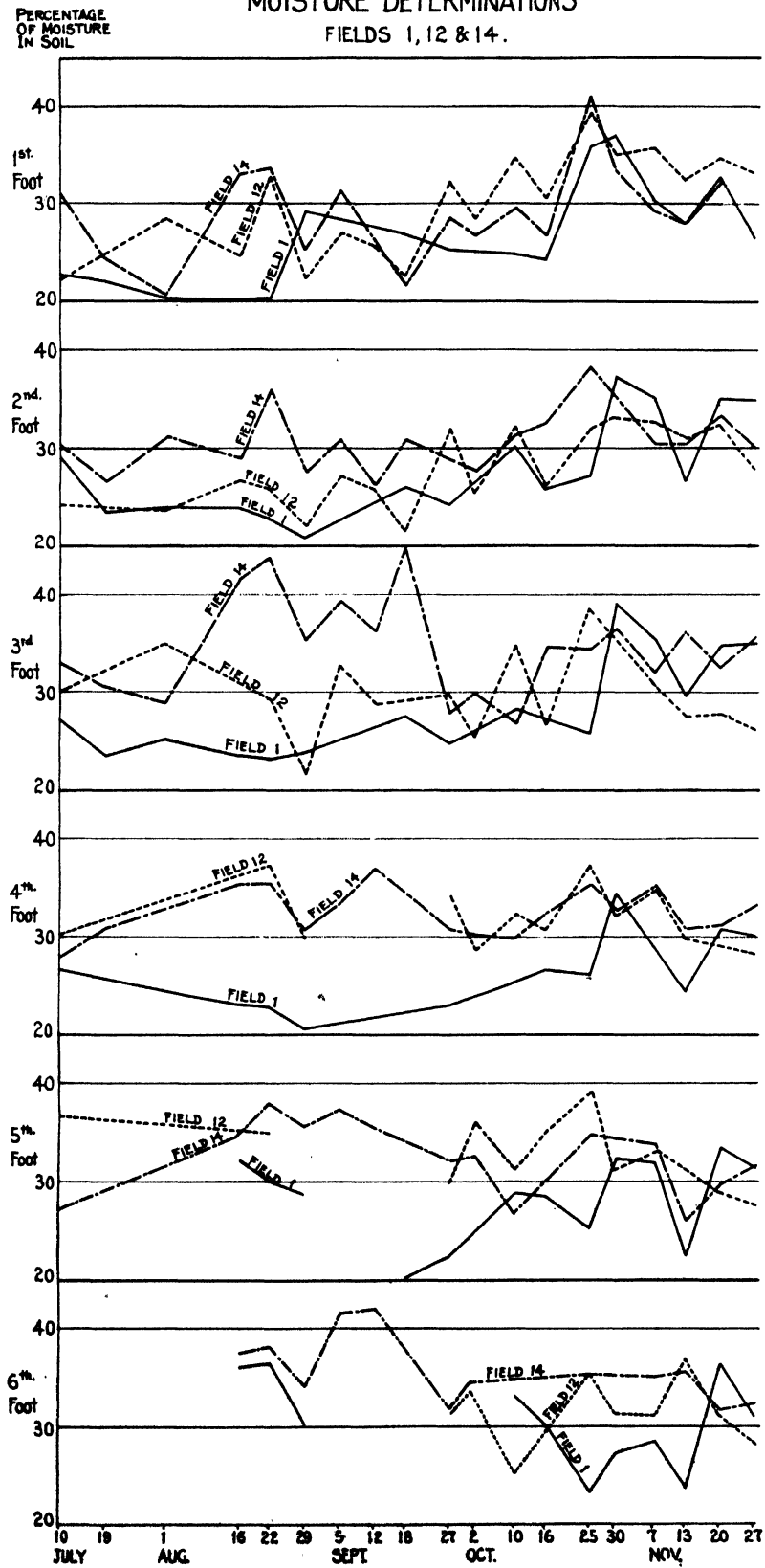


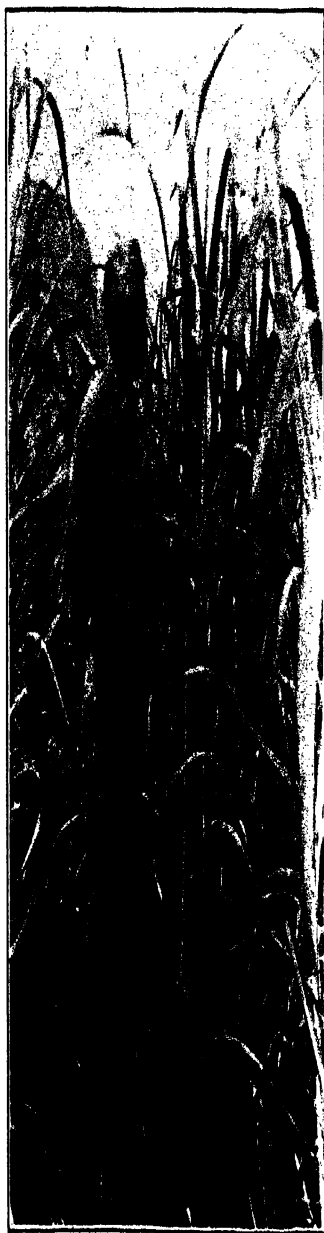
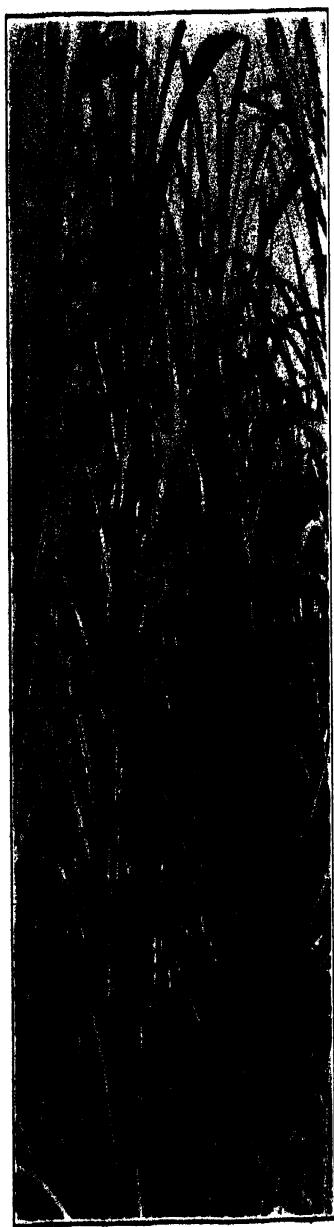
TABLE II.

SUMMARY OF GROWTH MEASUREMENTS.—ELONGATION OF STICKS OF CANE.

Field No.	Treatment	Average Length at start Feet	Average Length Nov. 28 Feet	Increase Feet	Gain due to Irrigation Feet
8	Extra Irrigation..... 255 lbs. N.	8.17	17.10	8.93	3.40
	Extra Irrigation..... 215 lbs. N.	7.85	16.38	8.53	3.00
	Extra Irrigation..... 175 lbs. N.	7.83	16.75	8.92	3.39
	Crop Cane	7.12	12.65	5.53	....
22	Extra Irrigation.....	6.41	14.33	7.91	2.69
	Crop Cane	6.59	11.81	5.22	....
15	Extra Irrigation.....	0.19	6.57	6.38	3.81
	1 Month Irrigation...	0.025	3.20	3.18	.61 (Started 1 month (late
	Crop Cane	0.01	2.58	2.57	....
1	Crop Cane	5.53	9.74	4.21	....
3	Crop Cane	4.31	7.94	3.63	....
12	Crop Cane	4.08	6.48	2.40	....
14	Crop Cane	4.80	7.93	3.13	....

In the extra irrigated cane in Field 15 it is seen that this plot made 2.5 times as much increase in growth as did the ordinary crop cane. In Mr. Weinrich's measurements he found in five watercourses of the extra irrigated cane, 375 stalks with measurable sticks. In the same distance in the crop cane there were 81 sticks. The extra irrigated cane in this length of row contained 5.24 cubic feet of stick which would be harvestable cane. The crop cane contained 0.66 cubic foot or just about one-eighth the volume present in the extra irrigated. Whether this difference persists will depend on the growth made this winter, when each plot is adequately supplied with water by rainfall. Further evidence of the present difference in the growth of the plant cane in Field 15, is given by a series of five photographs, taken by the writer. These show the extra irrigated cane, the 1 month's irrigated cane, and the crop cane. Two close up views of the stick development of the extra irrigated and crop cane are also included. Besides the development of stick shown in these views it may be pointed out that the extra irrigated cane is completely closed in and practically free from weeds. The crop cane is still very open so that weed growth will be heavy during the winter months.

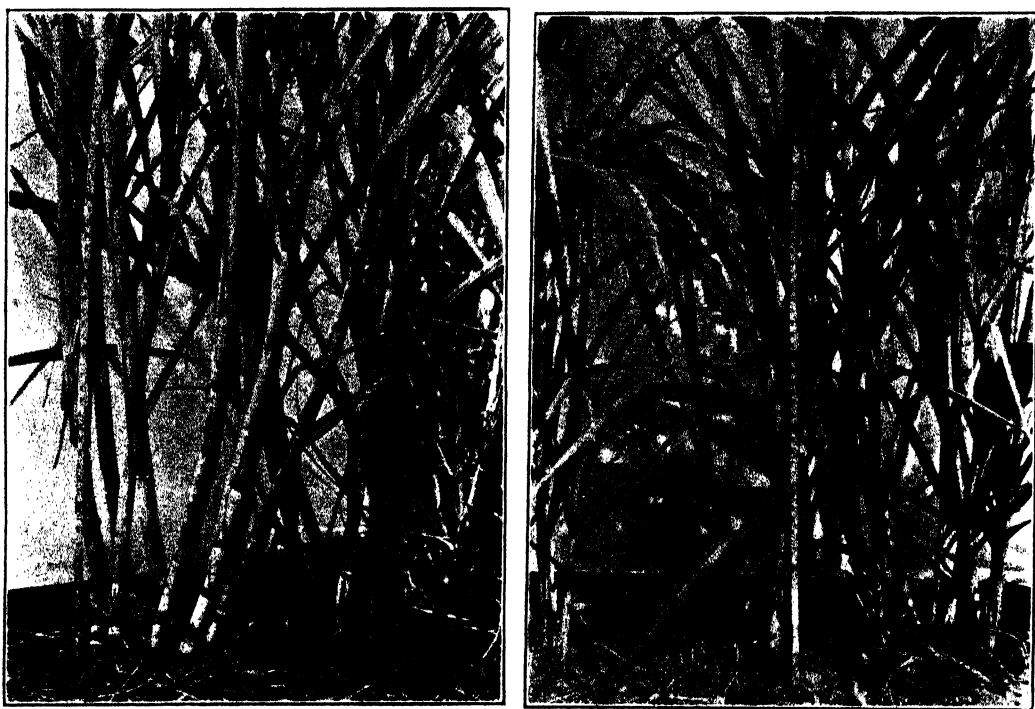
The detailed results of the elongation measurements are given in a series of graphs numbered 5-13 inclusive. These graphs are plotted so as to show the growth in two different ways, one of these represents the average weekly growth and the other the total mean growth during the period of the experiment. In Chart V of the total growth of the plots in Field 8, it will be seen that we had applied extra irrigation to three groups of plots in the amounts of nitrogen



These views show the extra irrigated cane (left), the one month irrigated cane (center), and cane irrigated at variable intervals as per field practice.

experiment conducted in this field. The three treatments show little difference in response, though it is not certain this would have been the case had full irrigation been supplied the first season. The cane in Field 8 was growing better than in Field 22 at the beginning of the experiment and I believe this explains the larger increase from the same total increase in irrigation water.

The periods of small weekly growth in the various plots of crop cane correspond to the drier periods between irrigations.



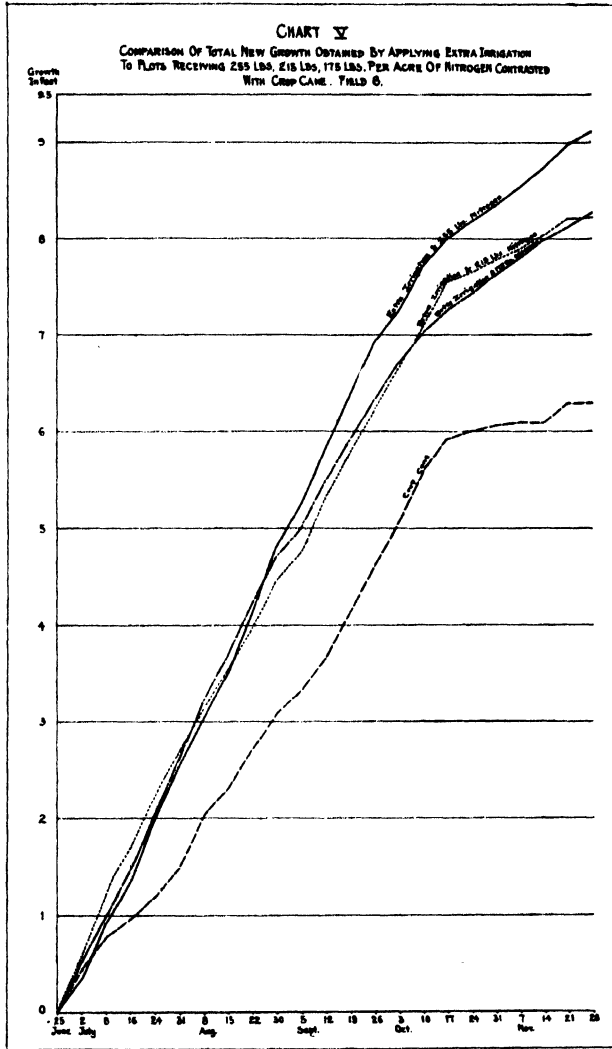
These views show the stick development of extra irrigated cane compared with normal field practice, which utilizes a small amount of water over a wide area.

GROWTH DEVELOPMENT OF NEW SHOOTS.

A careful count was made of all shoots present in the cane of the various plots of large cane at the beginning and close of the experiment. Weekly counts were made of the development of shoots in the young plant cane in Field 15.

In the older cane in Field 8, no new shoots developed during the period of our study. All the increased growth went into the stalks already present. In Field 22 the stand of cane was not so thick at the commencement of the experiment. In this field one-third of the stools measured had developed one shoot four to five feet high. This emphasizes the desirability of getting a good stand in the first season's growth, because these late shoots are not likely to be any benefit to this cane owing to their probable immaturity at harvest. Had full irrigation been applied earlier it is possible that second season shoots might have been a desirable thing. This is a point which will require further observation in the future.

In the young plant cane in Field 15, there was a notable difference in the development of new shoots in the crop cane and the extra irrigated area. We



made a weekly count of the increase in several watercourses of average length. In the crop cane the increase was slow until showery weather came in October. At the start the crop cane had 43 shoots per watercourse, which by October 10 had increased to 65. At this same date the full irrigation had increased from 41 to 92 shoots. Since this date the crop cane has continued to form new shoots because of the open type of growth. The number of shoots in the extra irrigated cane has remained constant, all new growth going into the sticks which were formed. There is no question as to relative volume in the sticks present in the two different areas. The relative economy in production of cane cannot be judged till we have next season's figures for comparison.

TASSELING.

We have observed some notable differences in the development of tassels in the plots in Field 8. This field as previously noted was growing more vigorously than any other cane on the plantation where we started our work. Only a small per cent of the sticks measured in the extra irrigated plots have tasseled, while

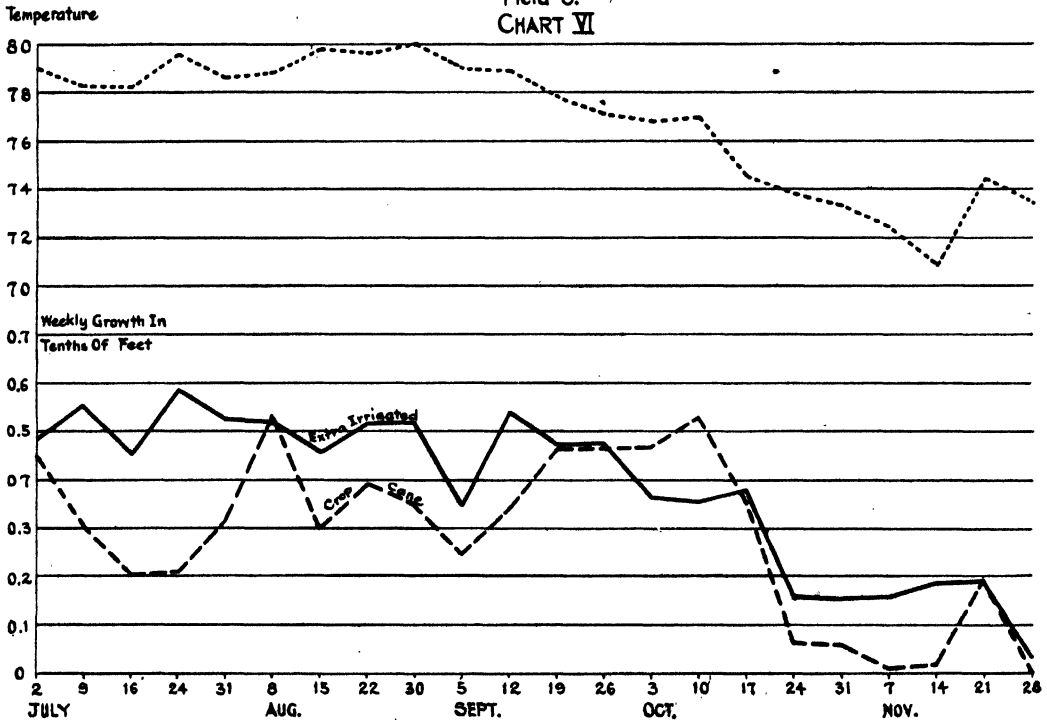
nearly all those under observation in the crop cane have developed arrows. The differences have not been quite so striking in Field 22, but here also there is less tasseling in the fully irrigated cane.

WATER DISTRIBUTION.

In studying the growth and irrigation of the various areas under observation, I have noted that in the attempt to make use of all possible water, cane has been planted in many fields in part of the level ditches and along the main irrigation ditches. After observing the distribution of water in the fields I do not feel that this plan has been a success. Having cane in some level ditches has tended to make the irrigation uneven. Such cane is also raised without its full nitrogen supply and so makes cane growth by the use of a greatly increased water consumption, compared to ordinary cane in the fields.

COMPARISON BETWEEN WEEKLY GROWTH OF EXTRA IRRIGATED & CROP CANE

Field 8.
CHART VI



The ideal field ditch should be absolutely impervious. Cane roots growing in or near the ditch increase the percolation and seepage because the roots open up the soil and cause minute drainage channels.

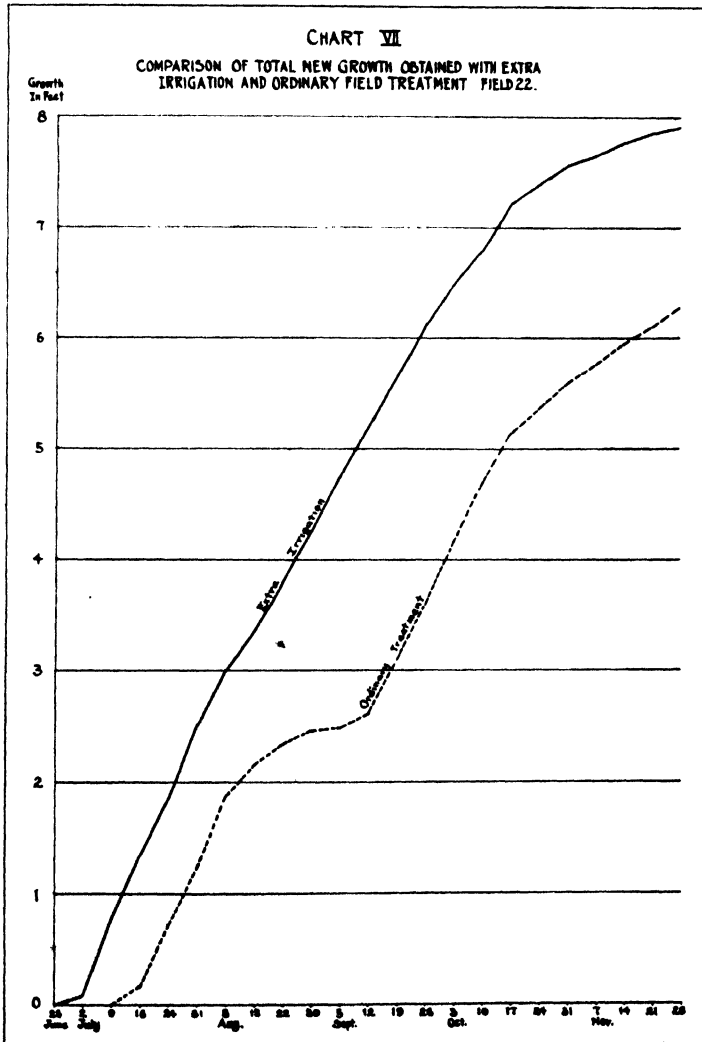
EFFECT OF TEMPERATURE.

In the accompanying charts, to show the total seasonal growth, the temperature has been plotted upon the upper portion of certain charts. The general showing up of growth late in the season is clearly shown to be influenced by the fall in temperature. Up to November 30, it is worthy of note that the young cane has

kept up a larger per cent of its growth than the larger cane. Nearly all of the large cane has made a notable decrease which in some cases almost amounts to a cessation of growth.

FERTILIZATION.

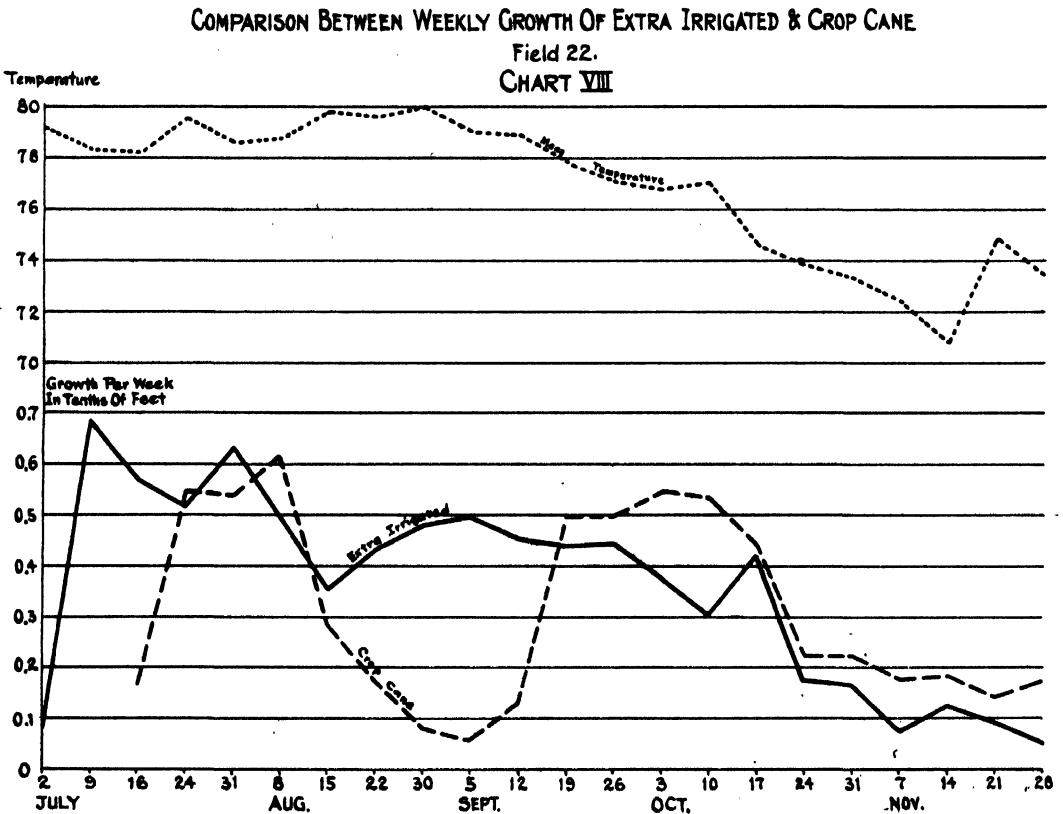
There has been no change in the fertilization of any of the large cane under observation. Field 22 has all received 175 lbs. nitrogen per acre. Field 8 has received varying amounts of nitrogen from 255-175 lbs. in the extra irrigated plots, while the crop cane has received 175 lbs.



In Field 15, the extra irrigated cane received 100 lbs. nitrogen per acre in August and 1,000 lbs. per acre of mixed fertilizer supplying 120 lbs. nitrogen in November. The crop cane received 1,000 lbs. mixed fertilizer in late October.

TENTATIVE DEDUCTIONS FROM THE ABOVE RESULTS.—IRRIGATION AND SOIL MOISTURE.

The results obtained from these two observations warrant us in stating that it will take approximately 2 acre inches per weekly irrigation, measured into the level ditches for full continuous growth with young plant cane. Second season irrigation will require 4.5 to 5 acre inches applied every two weeks for the best results. Improved results would be obtained on both crops if regular irrigations were possible even once per month.



GROWTH.

The growth figures show several things:

1. The importance of early irrigation and a full stand in young plant cane.
2. Continuous growth develops a larger stick and a notable difference in the response to irrigation.

3. Cane growth is largely affected by three things: water, fertilization and temperature. The present fertilization and temperature at Waimanalo are adequate for excellent crops, but the water supply is entirely inadequate.

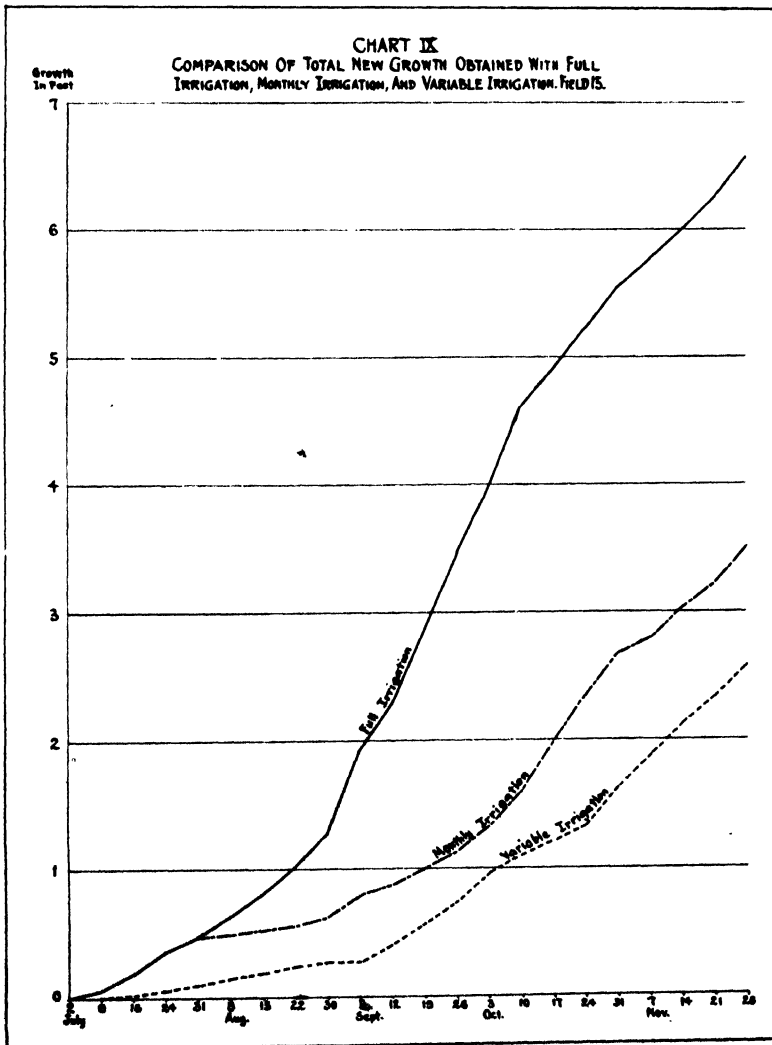
CALCULATION OF PROBABLE WATER REQUIREMENTS AT WAIMANALO.—FULL IRRIGATION.

In answer to the inquiry of Messrs. C. Brewer & Company as to the amount of water which can be economically used at Waimanalo, I desire to submit the following calculation:

Total area in Cane.....	2,700 Acres
Unirrigated	300 Acres
Irrigated	2,400

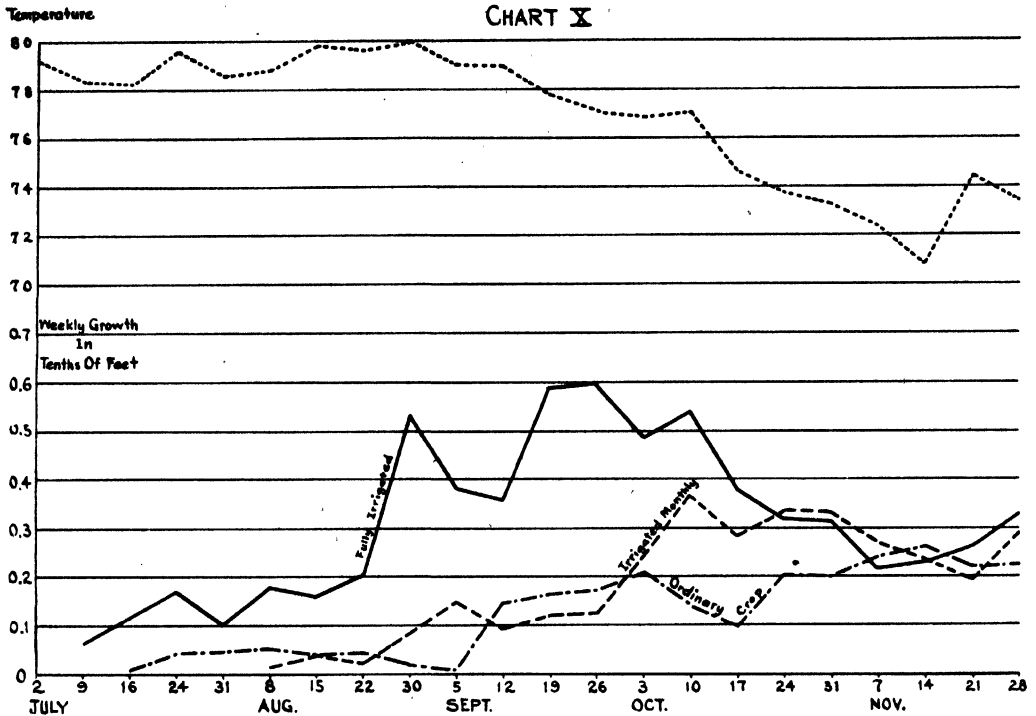
This area will be divided into two average crops on January 1.

The harvesting cane	1,400 acres	{ 150 acres unirrigated
		{ 1,250 acres irrigated
Young plant cane and ratoons.....	1,300 acres	{ 150 acres unirrigated
		{ 1,150 acres irrigated



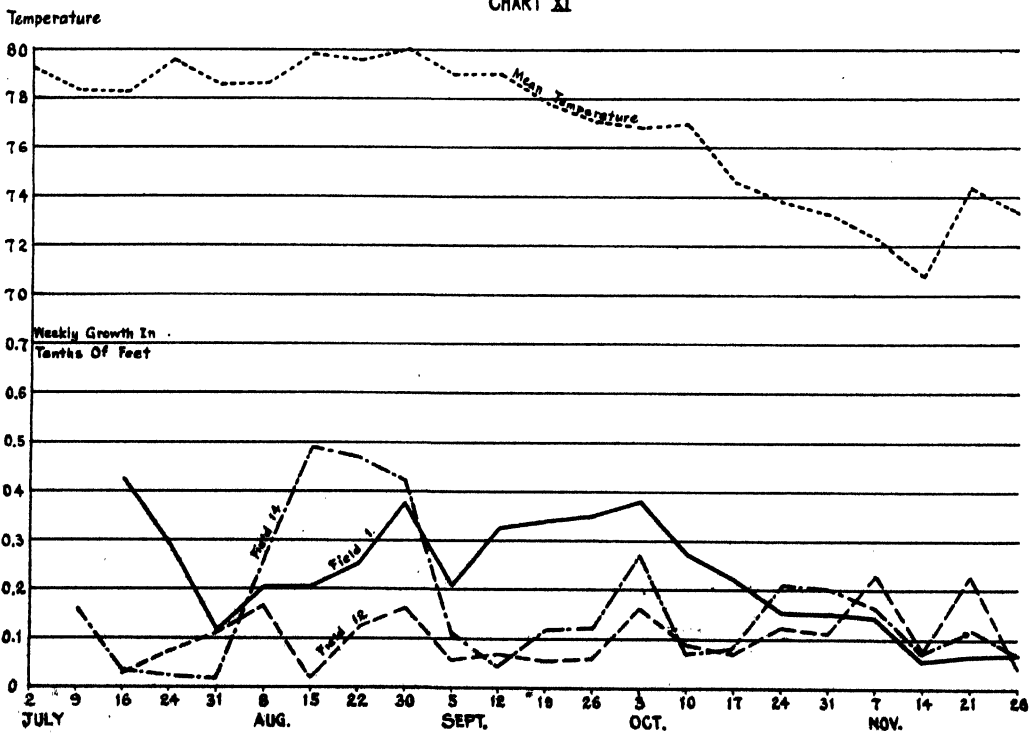
COMPARISON OF WEEKLY GROWTH MADE BY CANE FULLY IRRIGATED,
IRRIGATED MONTHLY & ORDINARY CROP CANE
Field 15.

CHART X



COMPARISON OF WEEKLY GROWTH OBTAINED WITH ORDINARY PLANTATION TREATMENT IN FIELDS 1, 12 & 14

CHART XI



We will assume that harvesting starts January 1 and will be complete about the middle of July. This means that approximately 200 acres of irrigated cane will be harvested each month. This cane ready for harvest will not require irrigation, except that the last fields to be taken off in May, June and July may require one or two rounds of water. This water will be available as the full irrigation demand will not be made before July. We shall therefore omit the harvesting crop from our calculations.

The young plant cane and young ratoons will receive 2 acre inches of water per week after March 1, and the second season cane will receive 4.5 to 5 acre inches every 14 days from March 1 to November 15. The daily demand for this water is given in the following table:

FULL IRRIGATION, ANNUAL SCHEDULE.

Date	Cane Subject to Irrigation		Total Area to be Irrigated	Irrigation		Total Gallons per Day
	Second Season Cane	Young Cane		Second Season Cane Gals. per Day	Irrigation Young Cane Gals. per Day	
Jan. 1.....	1,150	0	....	.....	.....	.....
Feb. 1.....	1,150	200	....	.....	.....	.....
Mar. 1.....	1,150	400	1,550	10,037,282	3,103,314	13,140,596
April 1.....	1,150	600	1,750	10,037,282	4,654,971	14,692,253
May 1.....	1,150	800	1,950	10,037,282	6,206,628	16,243,910
June 1.....	1,150	1,000	2,150	10,037,282	7,758,285	17,795,567
July 15.....	1,150	1,200	2,350	10,037,282	.....	.....
Aug. 1.....	1,150	1,250	2,400	10,037,282	9,697,856	19,735,138
Sept. 1.....	1,150	1,250	2,400	10,037,282	9,697,856	19,735,138
Oct. 1.....	1,150	1,250	2,400	10,037,282	9,697,856	19,735,138
Nov. 1 to 15....	1,150	1,250	2,400	10,037,282	9,697,856	19,735,138

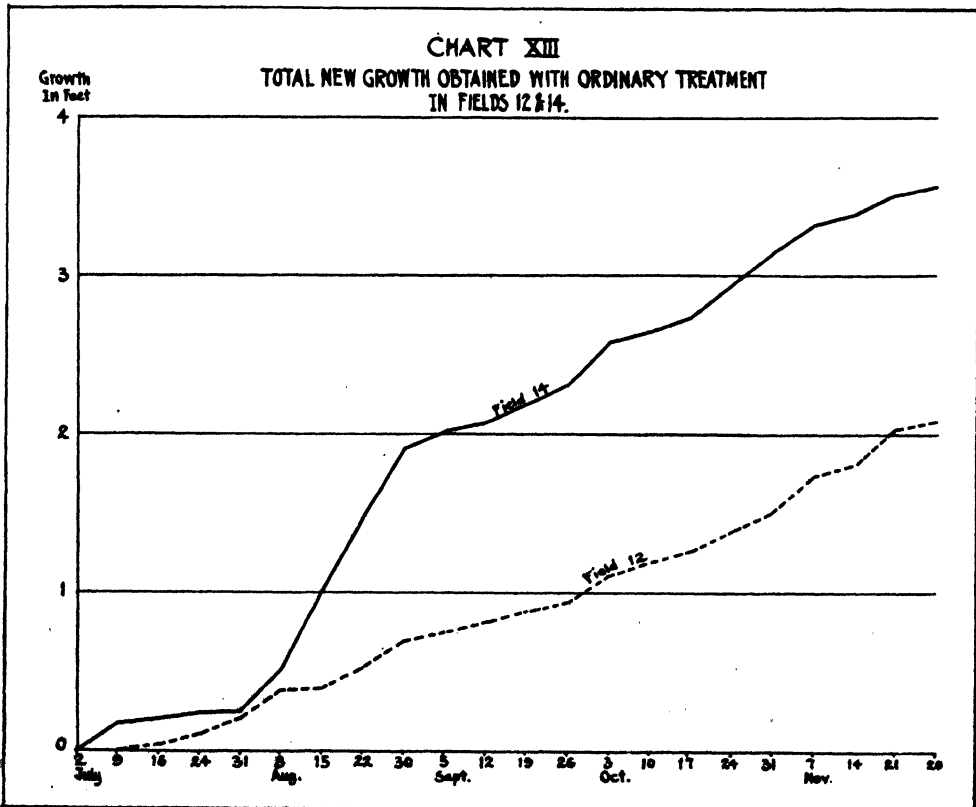
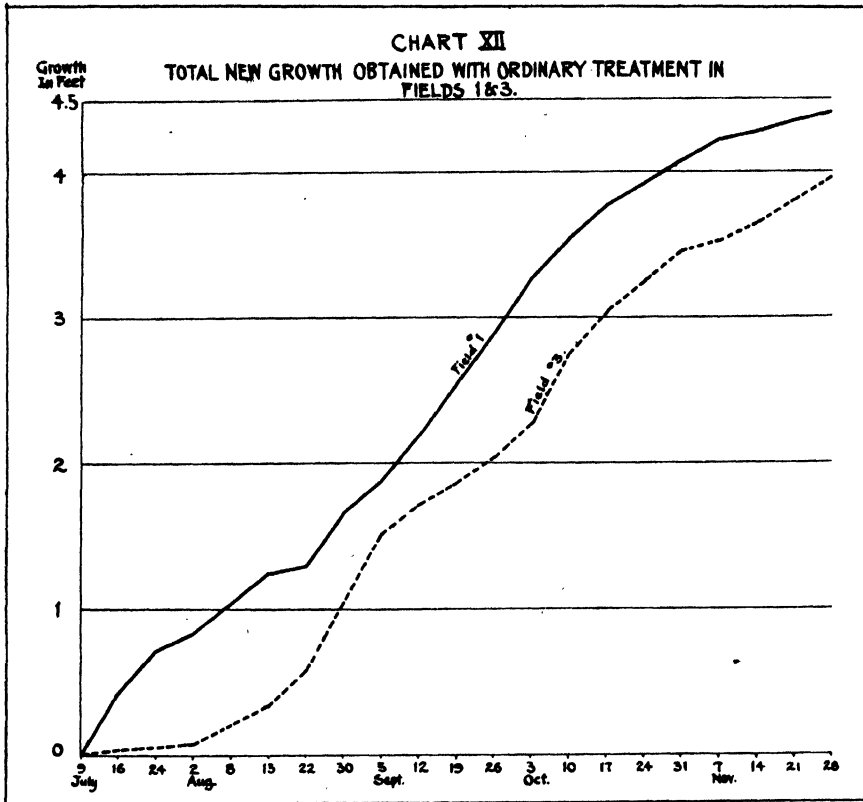
If we allow 30% for transmission losses in ditches, the final figure will be 25,600,000 gallons per day, required for reasonably full irrigation. A conservative estimate will be 25 to 30 million gallons of irrigation water per day.

MINIMUM WATER REQUIREMENT FOR REGULAR ROUNDS OF IRRIGATION.

Total areas as given above. One thousand two hundred fifty acres of mature irrigation cane, ready for harvest from January to July 15. This cane will receive no irrigation.

Irrigation Scheme—1,150 acres of cane, 6 to 12 months old which is to receive 4.5 to 5 inches of water every 30 days.

The young ratoons to receive 2 irrigations during the first season, each irrigation to be from 4.5 to 5 acre inches. Average area in plant cane will be about 250 acres to be started by April 1. This plant cane will receive 2 acre inches of water every 2 weeks till November 15.



IRRIGATION REQUIRED, MINIMUM REQUIREMENT REGULAR ROUNDS.

Date	Cane to be Irrigated		Gallons per Day	Gallons	Total
	6-12 Months	Young	6-12 Months	per Day	Gallons
	Cane	Cane	Cane	Young Cane	per Day
Jan. 1.....	1,150	0	.....	.....	.....
Feb. 1.....	1,150	0	.....	.....	.....
Mar. 1.....	1,150	300 ratoons 250 plant	4,684,065	1,221,930 9,969,071	5,905,995
April 1.....	1,150	300 ratoons	4,684,065	1,221,930	6,875,066
May 1.....	1,150	.....	4,684,065	1,221,930	6,875,066
June 1.....	1,150	.....	4,684,065	1,221,930	6,875,066
July 1.....	1,150	.....	4,684,065	1,221,930	6,875,066
Aug. 1.....	1,150	.....	4,684,065	1,221,930	6,875,066
Sept. 1.....	1,150	.....	4,684,065	1,221,930	6,875,066
Oct. 1.....	1,150	.....	4,684,065	1,221,930	6,875,066
Nov. 1.....	1,150	.....	4,684,065	1,221,930	6,875,066

If we allow 30% increase for transmission losses we find that approximately 9,000,000 gallons per day will be required under this minimum irrigation scheme. As the present irrigation supply may drop down close to 5,000,000 gallons per day in dry weather it is obvious that it will not be possible to follow this plan unless some additional water can be developed.

SUMMARIZED RECOMMENDATIONS FOR FURTHER WORK.

1. When the final water supply is known, adjust the irrigation schedule so as to make regular rounds of the fields under irrigation.
2. Keep all ditches and distributing laterals free from cane or other growth.
3. Make a complete study of transmission losses on the present system, so as to find what per cent of the supply is seeping out of the ditches. With this data in hand, it will be a simple matter to find whether it will pay to line all the main ditches and laterals with some type of concrete. It may be possible to bring the irrigation water up towards our figure for minimum irrigation by this method alone.
4. Investigate the possibility of overhead irrigation similar to the system now installed at Hawi. This system would be an alternative to lining the ditches. Overhead irrigation increases the duty of water and makes it possible to put in minimum irrigations without loss in transmission.
5. Continue the present experiments up to the time of harvesting, with such additional new areas as may prove advisable. In this further work it will be advisable to try and combine studies of growth by elongation with growth in cubic contents, so as to obtain more correct figures for semi-dry land cane.

Carbon Content of Plantation Soils

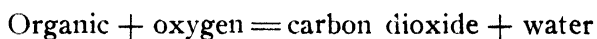
By W. T. McGEORGE.

INTRODUCTION.

The organic matter of the soil has served as an incentive for extensive investigations on soil carbon and nitrogen. The latter has been studied by Kelley (6) on Hawaiian soils, but little attention appears to have been given to the carbon. In the past the humus determination, which to a certain extent measures the more completely disintegrated or hydrolysed forms of organic matter, has been applied as an indication of the organic content of the soil. With the steady tendency towards absolute analyses, the total carbon determination has been more extensively applied of late. During the examination of Field 20, Oahu Sugar Co., where H 109 cane appeared to be suffering from root-rot, a notable absence of "life" in the soil was suggested. A comparative study has therefore been made of the carbon content of this soil as compared with other Island districts as well as those of the mainland.

The properties of soil organic matter are legion. It increases the water-holding capacity, improves the mechanical condition, imparting a crumb structure to clay and a greater cohesion to sand. It aids in maintaining a more uniform soil temperature, dark soils absorbing more heat. It increases the availability of plant food provided the proper environment is at hand and by serving as a source of energy, favors the growth of micro-organisms. Hopkins says, "It is the decay of organic matter and not the mere presence of it that gives life to the soil."

In studies on the carbon nutrition of plants, this element, like nitrogen, has been shown to pass through a rather definite cycle reaching its final simplified form, carbon dioxide, after passing through, in the presence of an oxidizing environment, complex bacterial decomposition products. This is well described by Russell as follows:



On this basis he has noted a marked relation between fertility and oxidation in the soil, for in the absence of air or oxygen, a reducing reaction will result in other products being formed, some of which are toxic. Carbon dioxide is the principal available form of carbon, being present as such in the air and soil atmosphere and combined as soluble and insoluble inorganic carbonates. It should be mentioned, however, that there is some evidence of the assimilation of carbon in the form of sugars, alcohols, aldehydes and organic acids.

In general, investigations have shown that the carbon content of the soil is higher than the subsoil, higher in clays than sandy soils, in pastures than cultivated areas, and in humid than dry sections.

The principal sources of organic matter in soils, are crop residues, weeds, green crops and manures. It is a notable fact that a number of crops have enough vegetable matter, roots and stubble, to restore any loss. This is especially true when these crops receive little or no cultivation. Soils may lose carbon by leaching, evolution of carbon dioxide, and removal by crops, but any such losses are undoubtedly slight.

According to soil literature 2% is a good average organic content. Lyon and Fippen (7; p. 125) have compiled the following table from soil analyses of samples taken from all parts of the United States:

	Sandy soils		Loam and clay soils	
	% organic matter		% organic matter	
	Soil	Subsoil	Soil	Subsoil
Northeastern States	1.66	0.60	3.73	1.35
Southeastern States	0.93	0.41	1.53	0.73
North Central States.....	1.84	0.76	3.06	1.07
South Central States.....	1.16	0.55	1.80	0.65
Semi-arid States.....	0.99	0.62	2.64	1.11
Arid States	0.89	0.64	1.05	0.62

Bradley (3) reports .73 to 1.53% carbon in Oregon soils, and noted a heavy decrease in carbon when cropped to wheat. Blair and McClean (2) report 1 to 2% carbon in New Jersey soils and a decrease of .2% carbon on cultivated plots from 1909 to 1916. Swanson and Latshaw (9) found that the loss of carbon is confined to the top soil. In the semi-arid districts of Kansas they noted 30% less carbon in the cropped soils than the virgin. Alway (1) reports 1.7 to 3.07% carbon in Nebraska soils with a carbon nitrogen ratio of 11.2 to 13.6. Gortner (5) reports 1.63 to 10.08% carbon in Minnesota soils with some peats at 49% carbon. It is evident from these figures that there is not a great variation in average mainland soils.

SOIL SAMPLES.

Eighty samples of soil were used in this study representing a wide variety of types from 23 plantations located on Hawaii, Maui, Oahu and Kauai. Total carbon was determined in all samples, carbonate carbon in 63 and pentosans in 21. The pentosan content of dried cane leaves was also determined in order to compare with the pentosan content of the soil.

METHODS.

Total carbon was determined by the wet combustion method using chromic and sulphuric acids and carbonate carbon with dilute hydrochloric acid, as described in "Methods of Analysis", Assoc. Official Agric. Chemists, 1919, page 309. Pentosans were determined by the furfural-phloroglucid method also described in the above Methods, page 96. The results are given in the following table, all being calculated to the water free basis. The moisture content of the air dry soil is also given in order to illustrate the relation of organic content to water-holding capacity:

TABLE I.
SHOWING RELATION OF CARBON CONTENT IN PLANTATION SOILS.

HAWAII

Soil No.	Plantation	Soil Description	Total Carbon	Carbonate		Moisture	Nitro- gen	Carbon	Carbon
				Carbon	Pentosans			Nitrogen Ratio	Pentosan Ratio
798	Hilo Sugar Co.	Yellow Silty Loam	12.00	....	....	14.1	...	....	....
802	Hilo Sugar Co.	Yellow Silty Loam	11.40	....	....	14.1	...	....	....
806	Hilo Sugar Co.	Yellow Silty Loam	10.90	....	....	14.6	...	....	....
810	Hilo Sugar Co.	Yellow Silty Loam	11.45	....	....	13.8	...	....	....
765	Onomea Sugar Co.	Yellow Silty Loam	7.78	.016	.45	12.0	...	....	17.3
1097	Onomea Sugar Co.	Yellow Silty Loam	8.81	.007	....	14.8	...	....	....
1101	Onomea Sugar Co.	Yellow Silty Loam	10.10	.015	....	15.5	...	....	....
549	Hakalau Plantation Co.	Brown Yellow Silty Loam	10.90	....	.63	16.5	.64	17.0	17.3
770	Hakalau Plantation Co.	Yellow Silty Loam	8.27	....	....	13.8	...	....	....
1013	Kaiwika Sugar Co.	Brown Silty Loam	7.17	.016	.49	18.4	.51	13.9	14.6
1017	Kaiwika Sugar Co.	Brown Silty Loam	9.61	....	.51	20.2	.61	15.7	18.8
1030	Kaiwika Sugar Co.	Brown Silty Loam	8.70	.046	.42	14.9	.61	14.2	20.7
1038	Kaiwika Sugar Co.	Brown Silty Loam	12.95	....	....	23.6	.74	17.5	....
1040	Kaiwika Sugar Co.	Dark Brown Sandy Loam	13.00	.027	1.00	25.8	.81	15.9	13.0
1070	Hamakua Mill Co.	Yellow Silty Loam	11.50	.011	.67	19.7	...	....	22.2
1074	Hamakua Mill Co.	Yellow Silty Loam	13.11	.009	....	20.8	...	....	....
1078	Hamakua Mill Co.	Yellow Silty Loam	8.94	.014	....	22.2	...	....	....
200	Honokaa Sugar Co.	Yellowish Brown Silty Loam	10.78	.032	....	16.9	.86	12.5	....
146	Honokaa Sugar Co.	Yellowish Brown Silty Loam	8.12	.022	....	13.0	.71	11.4	....
164	Honokaa Sugar Co.	Yellowish Brown Silty Loam	6.26	.021	....	13.2	.57	10.9	....
254	Pacific Sugar Mill Co.	Brown Silty Loam	6.78	.020	.40	13.6	.52	13.0	17.2
286	Pacific Sugar Mill Co.	Brown Silty Loam	12.69	.059	....	17.5	.79	16.1	....
1090	Niuli Mill & Plant Co.	Greyish Silty Loam	2.89	.001	.14	5.9	...	....	20.6
1093	Niuli Mill & Plant. Co.	Greyish Silty Loam	2.89	.005	....	5.8	...	....	....

TABLE I (Cont.)
SHOWING RELATION OF CARBON CONTENT IN PLANTATION SOILS

Soil No.	Plantation	Soil Description	Total	Carbonate	Pentosans	Moisture	Nitro- gen	Carbon	Carbon
			Carbon	Carbon				Ratio	Ratio
MAUI									
910	Pioneer Mill Co.	Red Clay Loam	1.89	.001	.17	9.3	.22	8.8	11.1
930	Pioneer Mill Co.	Red Clay Loam	.65	....	....	7.7	.10	6.7	....
933	Pioneer Mill Co.	Red Clay Loam	1.71	.015	....	7.3	.19	8.9	....
938	Pioneer Mill Co.	Reddish Brown Clay Loam	1.20	.000	....	5.2	.13	8.2	....
946	Pioneer Mill Co.	Reddish Brown Clay Loam	2.14	.001	....	7.5	.17	12.6	....
949	Pioneer Mill Co.	Reddish Brown Clay Loam	1.62	.014	....	7.3	.13	12.7	....
710	Mau Agricultural Co.	Red Clay Loam	1.19	.014	....	4.7	...	....	....
OAHU									
834	Waimanalo Sugar Co.	Greyish Brown Clay Loam	3.13	.026	....	15.3	.21	14.7	....
848	Waimanalo Sugar Co.	Grey Brown Clay Loam	2.33	.018	.11	12.5	.20	11.5	21.1
866	Waimanalo Sugar Co.	Red Clay Loam	3.20	.011	.24	7.1	.30	10.6	13.3
* 867	Waimanalo Sugar Co.	Red Clay Loam	1.95	.019	.18	7.6	...	....	10.8
872	Waimanalo Sugar Co.	Grey Clay Loam	2.25	.238	....	9.2	.18	11.3	....
* 873	Waimanalo Sugar Co.	Grey Clay Loam	1.53	.033	....	10.1	...	....	....
722	Experiment Station, Waipio.	Brown Clay Loam	1.03	.004	.07	6.0	.10	9.2	13.1
438	Ewa Plantation Co.	Dark Grey Clay Loam	1.47	.040	....	8.6	.13	11.3	....
* 439	Ewa Plantation Co.	Dark Grey Clay Loam	.96	.075	....	9.0	...	....	....
412	Ewa Plantation Co.	Red Clay Loam	1.52	.008	....	4.6	.11	25.4	....
322	Ewa Plantation Co.	Reddish Grey Clay Loam	1.58	.013	....	3.2	.10	15.8	....
428	Ewa Plantation Co.	Reddish Brown Clay Loam	1.02	.001	.07	6.1	.08	12.7	14.5
* 429	Ewa Plantation Co.	Reddish Brown Clay Loam	.58	.001	.09	6.5	...	....	6.4
239	Honolulu Plantation Co.	Yellow Red Clay Loam	3.53	.900	....	7.5	...	....	....
3	Experiment Station, Makiki.	Dark Clay Loam	1.19	.098	....	7.0	...	....	....
1108	Oahu Sugar Co.	Red Clay Loam	1.52	.006	.089	5.5	.21	7.2	17.1
* 1109	Oahu Sugar Co.	Red Clay Loam	.72	.006	.055	5.0	.10	7.2	13.1
1110	Oahu Sugar Co.	Red Clay Loam	1.61	....	....	4.7	.20	8.0	....
* 1111	Oahu Sugar Co.	Red Clay Loam	.89	....	....	5.8	.13	6.8	....
1112	Oahu Sugar Co.	Red Clay Loam	1.41	....	....	6.4	.16	8.8	....
* 1113	Oahu Sugar Co.	Red Clay Loam	.99	....	....	7.1	.11	9.0	....

* Subsoils.

TABLE I (Cont.)
SHOWING RELATION OF CARBON CONTENT IN PLANTATION SOILS

Soil No.	Plantation	Soil Description	Carbon				Nitrogen	Carbon	
			Total Carbon	Carbonate Carbon	Pentosans	Moisture		Nitrogen Ratio	Carbon Pentosan Ratio
1114	Oahu Sugar Co.	Red Clay Loam	1.86	.014	.119	6.8	.22	8.5	15.6
*1115	Oahu Sugar Co.	Red Clay Loam	.96	.006	....	7.5	.11	8.7	....
1116	Oahu Sugar Co.	Red Clay Loam	1.61	....	....	6.2	.18	9.0	....
*1117	Oahu Sugar Co.	Red Clay Loam	.90	....	....	6.9	.11	8.7	....
1118	Oahu Sugar Co.	Red Clay Loam	1.54	....	....	9.0	.16	9.6	....
*1119	Oahu Sugar Co.	Red Clay Loam	.79	....	....	7.1	.10	7.9	....
1120	Oahu Sugar Co.	Red Clay Loam	2.09	.032	.098	5.1	.22	9.5	21.3
*1121	Oahu Sugar Co.	Red Clay Loam	1.22	.024	....	4.5	...	....	....
KAUAI									
1003	Kekaha Sugar Co.	Reddish Brown Clay Loam	1.54	.085	....	10.6	...	....	....
405	McBryde Sugar Co.	Red Clay Loam	3.01	.032	....	4.8	...	....	....
984	Koloa Sugar Co.	Brown Clay Loam	4.03	.015	....	10.6	.33	12.5	....
986	Koloa Sugar Co.	Brown Clay Loam	4.46	.004	....	10.2	.40	11.2	....
973	Koloa Sugar Co.	Brown Clay Loam	4.22	.008	....	9.4	.42	10.0	....
974	Koloa Sugar Co.	Dark Brown Clay Loam	5.66	3.110	....	8.3	.22	25.8	....
954	Koloa Sugar Co.	Red Clay Loam	4.09	.001	....	10.2	.28	14.8	....
955	Koloa Sugar Co.	Yellow Clay Loam	4.46	.011	....	11.2	.27	16.7	....
957	Koloa Sugar Co.	Grey Clay Loam	5.94	.001	....	12.9	.42	14.2	....
998	Lihue Plantation Co.	Red Clay Loam	3.14	.057	....	6.0	...	....	....
367	Grove Farm Plantation	Yellow Clay Loam	4.14	.001	....	9.6	...	....	....
990	Grove Farm Plantation	Yellow Clay Loam	4.80	.028	....	9.5	...	....	....
1001	Grove Farm Plantation	Yellow Clay Loam	5.11	.000	....	9.2	...	....	....
1002	Grove Farm Plantation	Yellow Clay Loam	4.28	.008	....	8.2	...	....	....
995	Kilauea Sugar Plant. Co.	Yellow Clay Loam	3.38	.011	....	5.5	...	....	....
996	Kilauea Sugar Plant. Co.	Yellow Clay Loam	3.04	.052	....	6.0	...	....	....
382	Kilauea Sugar Plant. Co.	Brown Yellow Clay Loam	5.08	.165	....	5.5	.30	16.9	....
* 383	Kilauea Sugar Plant. Co.	Yellow Clay Loam	3.01	.034	....	7.3	...	....	....
Cane Leaves			....	....	30.1	....	...	....	....

* Subsoils.

Considering the total carbon determinations by districts and islands it is at once apparent that the high carbon content is associated with humidity. The highest figures were obtained on the soils from the Hamakua coast district. The lowest results were from the more or less arid districts on Maui and Oahu. There is a distinct relation between the color and carbon content, all the red soils being among the lowest and practically all the high carbon soils being of the yellow or yellowish brown type. It is of further interest to note the association of high moisture holding capacity with high carbon and vice versa. On the whole, variation in carbon content extends over a wide range, 1.02 to 13.11 per cent, the subsoils being invariably lower than the respective surface soil.

In other than the soils from the coral areas, there is only a very small amount of carbonate carbon. This applies to practically all soil types regardless of location. For this reason, for all practical purposes, total carbon in Hawaiian soils may be considered all organic. Rarely does the carbonate carbon exceed .025 per cent in the noncoral areas.

The pentosans are a group of exceedingly complex carbohydrates of unsatisfactory classification. They have been assigned the generic formula $C_5H_8O_4$, and are usually present in cellular and woody tissue. A sample of dried cane leaves from Waipio on analysis was shown to contain 30.1% pentosans on the water free basis. The purpose of the pentosan determination in the soil was to note any presence of residual cane leaves in the soil. It will be noted in the table that the high carbon soils from the Hamakua district are highest in pentosan carbon, which we may term undecayed organic matter. In a manner, this might indicate slower decay in such soils, but when we figure on the basis of ratio of pentosans to total carbon there is no greater variation than is noted in the soils from the other districts. Hence, while there is considerable variation in the pentosan content of island soils, there is no distinctive relation except that both the pentosan content and carbon-pentosan ratio are markedly lower in the subsoil.

The carbon-nitrogen ratio usually falls within the range of 10 to 12 in mainland soils. In the Hawaii and Kauai soils both nitrogen and carbon are high as is also the nitrogen-carbon ratio, while in the Maui and Oahu soils, especially the red clay type, the ratio is low. According to Brown and Allison (4) a ratio of 1:12 or above indicates satisfactory bacterial activities while ratios below 1:10 indicate sluggish bacterial action. If this applies to our soils, our humid soils possess the more satisfactory environment for bacterial action. They noted a higher degree of fertility in those soils of high ratio. This at least does not hold true for island soils. Read (8) on comparing the carbon nitrogen ratio of soils from widely scattered states on the mainland was unable to correlate soil productivity with this ratio.

On the whole, as compared to mainland soils, analyses indicate Hawaiian soils to be well supplied with organic matter. But, in a manner, this is misleading in that there is a radical difference in the chemical composition and physical nature. The nature of local soils is such that the organic matter is a very important factor in controlling the water-holding capacity. The rainy districts on Hawaii, which are very high in organic matter, have an extremely high water-holding capacity. On the other hand, most of the red soils in the drier districts would undoubtedly be greatly improved in water-holding range by a higher organic content.

RELATION OF CARBON CONTENT TO CROPPING.

During the course of the above investigation the question arose as to the exhaustion of organic matter in the sugar lands by the present cropping system

and especially the practice of trash burning at harvest. Some time ago Mr. Stewart collected a set of soil samples at Ewa Plantation in order to study salt or alkali accumulation. *These samples included border or uncultivated and field samples from nine different fields. Total carbon determinations were made in these soils and the results compared. A description of the soil samples follows:

Field 25, a dark brown clay adobe. Sample 440 from the field and 826 from the border of the road alongside Field 25.

Field 27, a greyish black clay. Sample 438 from the field and 824 from the border of the road alongside.

Field 19F, a brown silty clay loam. Sample from the field, 422 and sample 788 from alongside the plantation road running from the government road to the plantation stables.

Field 13B, greyish black clay adobe. Samples 322, 324, 326, 328, 330 from the field and 781 from the lower border and 782 on mauka edge between the cane and railroad track.

Apokaa Field, brown clay loam. Field sample 442 and border sample 830.

Field A, reddish brown silty clay loam. Field samples 424, 426, 428, 430. Border samples 794, 796, 832 at different points alongside the field.

Field 17A, dark red clay loam. Field samples 408, 410, 412, 414, and border samples 790, 792.

Field 2A, reddish brown silty clay loam. Field sample 436. Border samples 784 and 786 from the churchyard, planted to Bermuda grass, at the edge of the field.

Field 7, dark brown clay loam. Field samples 304, 306, 308, 310, 312, 314, 316, 318. Border samples 773, 775, 777, 779 taken at different points along the edge of the field.

The carbon content of these soils is given in the following table:

	Soil No.	Field	Soil No.	Border	No. Years Cropped
Field 25	440	1.24	826	1.55	25
Field 27	438	1.50	824	1.96	22
Field 19F	422	1.31	788	0.74	29
Field Apokaa	442	1.29	830	0.79	23
Field A	424	1.05	794	0.98	..
	426	1.41	796	1.08	..
	428	1.02	832	1.06	..
	430	1.14	...	....	..
Average		1.15		1.04	29
Field 17A.....	408	1.11	790	0.91	..
	410	1.10	792	1.45	..
	412	1.59	...	....	..
	414	0.97	...	....	..
Average		1.19		1.18	30
Field 2A.....	436	1.65	784	1.49	..
	...	....	786	1.52	..
Average		1.65		1.51	31
Field 7.....	304	0.85	773	1.13	..
	306	1.16	775	1.34	..
	308	1.41	777	1.96	..
	310	1.24	779	1.53	..
	312	1.28	...	....	..
	314	1.44	...	....	..
	318	1.59	...	....	..
Average		1.28		1.49	31
Field 13.....	322	1.15	781	2.68	..
	324	1.41	782	1.10	..
	326	1.59	...	....	..
	328	1.07	...	....	..
	330	1.93	...	....	..
Average		1.43		1.89	30

These results are of interest in that only 4 fields are lower in carbon than the uncropped border while 5 are higher. Field samples vary from 0.85 to 1.93 per cent while the border samples vary from 0.74 to 2.68. The average of all field samples is 1.30 per cent while that of the border samples is 1.37. Average figures then indicate a very slight loss, but if we allow for the range of variation in both cropped and uncropped soils, we might safely interpret the above data as showing no loss in organic matter. This is of especial interest in view of the fact that no other plantation soils are subjected to more intensive culture than the Ewa soils; that the heaviest tonnages in the islands are harvested from their fields and further that trash burning at harvest is the universal practice.

In view of the above it is of interest to note some unpublished data obtained by Mr. Agee some years ago showing the dry matter produced by a Yellow Caledonia plant crop 14½ months old producing 46.4 tons cane per acre.

	Dry Matter Tons per Acre	% of Total
Cane tops	3.46	14.60
Cane	10.72	45.23
Dead leaves	4.88	20.59
Young shoots .....	.15	.63
Root stock, etc.....	2.76	11.65
Roots	1.73	7.30
Total	23.70	100.00
All underground parts.....	4.49	18.95

In other words, dry weight of underground parts amounts to nearly 5 tons per acre per crop. Hence, supposing all leaves and trash are destroyed by burning, which is not entirely true, the organic material added to the soil by a cane crop is far in excess of the average weight of a green manure cover crop. Green cover crop plowed under will add 300 to 1,000 lbs. organic matter per acre (dry basis). The following table taken from Lyon & Fippen (7, p. 386) shows the relative *green* weight of the more important cover crops:

Red clover	6 tons per acre
Crimson clover	6 " " "
Alsike clover	5 " " "
Alfalfa	8 " " "
Cow peas	6 " " "
Soy beans	6 " " "
Field peas	5 " " "

It is also of interest to know that at Rothamsted a field continuously in wheat since 1843, plot 2b has received 14 tons farmyard manure annually and the first 9 inches of soil have gained only .098 per cent carbon in 12 years, and in 50 years 1.342 per cent more than continuously cropped unmanured plot. On the basis of 5 tons underground parts and figuring 3,000,000 lbs. soil per acre foot, a 45-ton cane crop adds approximately 0.3 per cent organic matter to the top foot of soil per crop.

CONCLUSIONS.

Analysis of Hawaiian soils as compared with mainland soils indicates an ample supply of organic matter.

The highest organic content is found in soils from the humid districts while the red soils of the dry sections are lowest. The moisture holding range of the latter would be greatly increased by a higher organic content.

On the basis of data obtained from the analysis of a set of soil samples from 9 fields at Ewa Plantation there is no indication that the present cropping system is depleting the organic matter of plantation soils.

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Summary of Results in Cutting Back Experiments

By J. A. VERRET.

To date eight cut back experiments have been harvested. Two more are being conducted, one at Koloa and one at Pioneer.

The results obtained were as follows:

Location	Date Planted or Date Cut		Variety	Treatment	Yield per Acre		Loss from Cutting Back		
	Ratooned	Back			Cane	Sugar	Cane	Sugar	% Tassel
Waipio Substation . . .	Ratoon—April	July 8 . . .	Lahaina	Cut back	48.7	5.74	+ 3.9	—0.20	3.5%
			Lahaina	Not cut back . . .	52.6	5.94	.....	.....	.....
Experiment D	Ratoon—April	July 8 . . .	Yellow Caledonia . . .	Cut back	72.6	7.89	— 3.3	—0.23	None
			Yellow Caledonia . . .	Not cut back . . .	75.9	8.12	.....	.....	.....
	Ratoon—April	July 8 . . .	D 1135	Cut back	80.5	7.77	—12.9	—2.00	0.35%
			D 1135	Not cut back . . .	93.4	9.77	.....	.....	.....
O. S. Co.									
Field 49, Exp. 12 . . .	Ratoon—May 1-8 . . .	July 7 . . .	D 1135	Cut back	89.6	12.28	— 7.5	—1.16	None
				Not cut back . . .	97.1	13.44	.....	.....	.....
O. S. Co.									
Field 15 Obs. Test 1 . .	Plant—May 1-15 . . .	June 29 . .	H 109	Cut back	86.9	9.07	—18.3	—2.07	None
				Not cut back . . .	104.2	11.14	.....	.....	.....
Ewa Plant. Co.									
Apokaa 2 field	Ratoon—May 10 . . .	July 7 . . .	H 109	Cut back	97.4	12.14	—14.0	—1.99	.....
				Not cut back . . .	111.4	14.13	.....	.....	.....
Ewa Plant. Co.									
Field 1-C	Ratoon—March 25 . . .	July 6 . . .	H 109	Cut back	88.7	10.07	— 7.65	—0.77	.....
				Not cut back . . .	96.4	10.87	.....	.....	.....
Ewa Plant Co.									
Field 1-A	Ratoon—May 4 . . .	July 5 . . .	H 109	Cut back	83.7	10.46	+ .70*	+0.31*	.....
				Not cut back . . .	83.0	10.15	.....	.....	.....
Ewa Plant Co.									
Field 10-A	Ratoon—May 23 . . .	July 6 . . .	H 109	Cut back	122.3	14.23	— 6.14	—1.13	.....
				Not cut back . . .	128.4	15.36	.....	.....	.....
Ewa Plant. Co.									
Field 19-B	Ratoon—May 4 . . .	July 8 . . .	Lahaina and H 109 . .	Cut back	88.0	11.09	— 6.88	—1.12	.....
				Not cut back . . .	94.9	12.21	.....	.....	.....

* Gain.

The details of these experiments will be found as follows:

Waipio D—Planters' Record, Vol. XIX, No. 1.
O. S. Co. 12—Planters' Record, Vol. XXIV, No. 3.
O. S. Co. Obs. 1—Planters' Record, Vol. XXIV, No. 6.

Details of the Ewa Experiments will be found elsewhere in this issue. The work at Ewa is summarized as follows by the plantation:

A gain of 1.08 tons of sugar per acre was secured by not cutting back, being the result of the additional 7.45 tons of cane per acre. These figures are the averaged yields of the five tests. These tests covered five typically different locations on the plantation with varying conditions of drainage, slope and character of soil.

The saving of labor was an extra advantage. This was effected in two ways:

- (1) No labor used in the operation of cutting back.
- (2) Less labor used in hoeing as the result of the quicker closing in of the non-cut-back cane, thus shading out the weeds.

The cane yields are briefly tabulated:

Field	Character of Field	Tons of Cane per Acre	
		Non-cut-back	Cut-back
AS No. 2.....	Deep soil, steep slope.....	111.37	97.39
No. 1-C.....	Shallow soil, steep slope.....	96.38	88.73
No. 1-A.....	Deep soil, fair slope.....	82.96	83.66
No. 10-A.....	Deep soil, level.....	128.42	122.28
No. 19-B.....	Deep soil, level.....	94.91	88.03
Average		101.53	94.08

Gain for Non-cut-back.....7.45 tons cane per acre.

The experiments vary in the gain of the check plots over the plots cut back. In Field Apokaa 2, there was an average gain of practically 13 tons cane per acre; in Field 1-C a gain of 7.65 tons cane per acre; in 10-A a gain of 6.14 tons cane, and 19-B a gain of 6.88 tons cane, while in Field 1-A, the yields for all practical purposes were the same.

Four experiments gave the following average increase in tons sugar per acre:

Field AS No. 2.....	1.99	tons	sugar	per	acre
Field 10-A	1.13	"	"	"	"
Field 10-B	1.12	"	"	"	"
Field 1-C . . . . .	.77	"	"	"	"
<hr/>					
Average of four tests.....	1.43	"	"	"	"

The fifth experiment in Field No. 1-A gave no gain, and discounting the extra poor juices in Plot 8-X, there would be no loss either.

In three cases the plots where no cutting back was practiced averaged better juices, in one case average juice was about the same, and in one case poorer for the non-cut-back plots.

In the work so far done we find that seven out of eight experiments show a loss for cutting back. In the eighth experiment the differences were small. In all cases cutting back was done in early July when the cane was from two to three and a half months old.

In these tests the cane was not forced before cutting back, that is, but very little irrigation was done, and no fertilization, until after cutting back. If the cane was forced from the beginning it is reasonable to assume that greater differences would be shown in favor of not cutting back.

In connection with cutting back it would be of value to keep records of the tasseling on different parts of the plantations. A good way to keep these records would be to use different colors on a map of the plantation; different colors indicating different degrees of tasseling.

With this to help, cutting back, when necessary, could be done much more intelligently. Parts of the plantation which show a tendency to tassel freely could be cut back while the other parts would be left alone.

We have noted time and again that tassels were plentiful in one part of a field while near by there were none.

This field census on tassels would locate these areas and be very convenient at "cut back" time.

Seedling Work in the Kohala District for 1923*

By W. C. JENNINGS.

Mr. Kutsunai spent a few days in Kohala at the beginning of the tasseling season and consequently the work received the benefit of his experience from the start. Whatever changes that were necessary, in the plan of work based on his instructions, were brought about by the uncertain weather of Kohala, which is rather unfavorable for seedling work.

NURSERY CONSTRUCTION.

The cold frames are long, unfloored benches, four feet wide, with a wall eighteen inches high on the north or back side, and are partitioned off into nine-foot sections, each section having a muslin covered frame cover which slopes to the south with pitch enough to carry off heavy rain.

The benches are made four feet wide, though too wide to work conveniently, for the reason that, with the high back wall necessary to break the wind, a narrower bench would be too dark. If old lumber is used in the construction of the cold frames, the interiors are whitewashed. The partitions are placed to break currents of air that might sweep up and down the length of the benches otherwise.

Better drainage is assured by not flooring the benches, but supporting the fuzz or germination flats with 1x3 slats laid across the benches and spaced according to the size of the flats in use.

* In this report on the 1923 seedling propagation work in Kohala, to be brief, only methods which differ from Makiki practices will be touched on.

The benches are laid out so as to extend slightly to the northwest and southeast across the nursery. With this arrangement it is believed we get the best protection from the prevailing easterly wind, while at the same time the cold frames are allowed the maximum benefit of the sun, (1) by being able to open the frames directly to the morning sun, and (2) when frames are closed the sun is allowed to strike the muslin covers at an angle favorable to filtration of indirect sunlight.

SELECTION OF TASSELS.

As in the work on Oahu, tassels were selected in localities favorable for the desired crosses, always cutting tassels from varieties on the leeward side of the supposedly pollinating variety.

Tassels were cut as soon as the top half or less had ripened, as the heaviest germinations were secured from the tops. Before the lower part of a tassel has ripened, as a rule, the top part which sets the most seed has either been blown to pieces by the wind or damaged by rain. Whenever tassels at the right stage for cutting are found, it has been the experience here, that it is best to collect as great a quantity as possible at that time, testing a few for germination, and using or discarding the balance according to the results of this test. Owing to the uncertain weather conditions here, it is almost impossible to cut a few tassels for a germination test with the idea, if the test be successful, of going back later to cut enough for your needs, as it was proven many times here last year that tassels cut at one time may give good germination, while those cut in the same field at the same apparent stage of maturity, a week later, may not.

Tassels cannot be dried in muslin bags here as is done at Makiki. Due no doubt to the green condition of the tassels when cut and the more humid climate, it has been found necessary to hang the tassels up in small bundles for a few days, or until the fuzz begins to drop, before placing in bags. This is not a very convenient method as only one lot of tassels can be kept in a room at one time as the flying florets would soon become mixed. During rainy weather it is sometimes difficult to keep tassels from spoiling even when not in bags.

PLANTING AND CARE OF GERMINATION FLATS.

As a result of several unsuccessful attempts with the soil mixtures used at Makiki and failure with any soils containing much humus or organic matter, it is the conclusion here, that in Kohala and Hamakua where there is apt to be a large percentage of cloudy and rainy days with low temperature during December and January, when most of the planting must be done, that soil as free as possible of organic matter, yet still retaining some degree of fertility, must be used in germination flats.

In every case where fuzz was planted in flats containing any amount of stable manure or compost, and a few days of cloudy and rainy weather occurred, the fuzz became a slimy mass of fungi and algae, even though in some cases no water was applied during the whole period.

Soil that is considered the best available here was taken from around the foundations of an old stable, where no fresh organic material, with the exception

of decaying weeds growing on the spot, has been added for probably twenty years. Though very fertile, this soil is too heavy to be considered ideal for seedling work, having very little trace of humus and being almost clay loam in texture. In this soil most of the 1923 seedlings were propagated.

Addition of enough coral sand to improve the texture of this soil, although apparently not injuring germination, appeared to lessen the fertility of the mixture to such an extent that the seedlings made too slow a growth and were caught by dampening off, or smothered by blue green algae.

No Kohala cut tassels gave very heavy germination, the heaviest being from H 109, which gave about 100 germinations per flat. With Oahu tassels as high as 1,800 to 2,000 germinations per flat were secured. To get the estimated 25,000 Striped Tip germinations, it was necessary to cut many thousands of tassels and plant hundreds of flats. The Striped Tip fuzz gave on an average about twenty to thirty germinations per flat.

CARE AFTER FIRST TRANSPLANTING.

Seedlings were transplanted from germination flats when about one inch high. They were shaded for three or four days after this operation and several days were spent breaking them in gradually to the sun. If at any time two or three days of cloudy weather occurred the seedlings were shaded the first clear day and once again broken in to full time exposure to direct sunlight, and this breaking in process was repeated after every period of cloudy weather until the plants were seven or eight inches high.

With the exception of a possible more sparing use of water and more care about exposure to direct sunlight, planting operations, care of fuzz flats, and care of flats after first transplanting, were much the same as outlined in Mr. Kutsunai's report.

CARE OF POTTED SEEDLINGS.

When the seedlings are from three to five inches high the largest and most vigorous appearing plants are transferred to pots. In a week or two the same flats are gone over again and these seedlings that have not started a more vigorous growth and deemed not large enough for transferring to pots are destroyed.

The transplanting to pots is done under cover and the plants are shaded until they appear to have recovered from the effects of this operation, after which several days more elapse before they are left uncovered all day.

When the potted seedlings are accustomed to being all day in the sun, have recovered from the effects of transplanting, and appear to be making good growth again, some of the protection against the wind is removed. This checks the growth considerably in all the plants, but those which do not grow at all or seem to be dying are destroyed and the pots used again. It is estimated that between 16,000 and 18,000 seedlings were eliminated in this way, between the time of first transplanting and setting out in the field. Only a limited number of seedlings can be handled in the fields and it seemed a reasonable supposition that the majority of the seedlings discarded in this manner would be weaker and less vigorous plants.

No fertilizer of any kind was applied until a very short time (generally a week or ten days) before setting the seedlings out in the field, as it was thought inadvisable to promote a lush, rank growth which would receive a severe check when the plants were put out in the field.

GENERAL OBSERVATIONS.

Tassels appeared continuously in different parts of the Kohala district from the first of November until the latter part of January. During this season no general order, either varietal or locational, for the appearance of tassels was observed.

Striped Tip tassels cut at a distance from other tasseling varieties in every case failed to germinate, while all the Striped Tip germinations secured were from tassels which had developed a few feet to the leeward side of another tasseling variety. These results lead us to believe that we have our desired Striped Tip X H 109 and Striped Tip X D 1135 crosses among the seedlings now in the field.

Striped Tip seedlings, of the same age, were very uniform as to size, when compared with seedlings of other parentage, and very few were discarded. To date this uniformity is still noticeable in the field.

In setting out seedling station No. 1 at Niulii Mill & Plantation, very rigid selection was practiced, which resulted in a lot of seedlings very uniform as to size. At this time, although many of the seedlings have stalks which have formed four or five joints, this station has almost as uniform appearance as the surrounding crop cane.

A list of seedlings set out this year, with female and probable male parent, follows:

From Kohala tassels:

Striped Tip X D 1135.....	12,200
Striped Tip X H 109.....	800
H 109 X Striped Tip.....	1,100
H 109 X ?	1,000
D 1135 X Striped Tip.....	90
Badila X ?	220

From Oahu tassels:

H 1801	2,600
H 5978	2,000
H 109	3,680
D 1135	110
Lahaina	100

The number of seedlings set out on each plantation follows:

Niulii Mill & Plantation.....	2,000
Halawa Plantation, Ltd.....	2,000
Kohala Sugar Co.....	6,700
Union Mill Co.....	4,100
Hawi Mill & Plantation Co., Ltd.....	8,200

Handy Irrigation Factors

By J. S. B. PRATT, JR.

The use of the small meter of the submerged orifice or rectangular weir type brings the terms "acre foot", "acre inch", "second foot", and others into more common usage in the Islands. At the last annual meeting of the Association of Hawaiian Sugar Technologists, the writer presented several charts showing what a "man's water" represented. These, with various irrigation factors, and conversion tables are given here as a handy reference for irrigation use. The following references will give more complete tables:

Handbook of Hydraulics—King.

Measurement of Irrigation Water. U. S. Reclamation Service, 1923.

Construction and Use of Farm Weirs. Farmers' Bull. 813.

Measurement of Irrigation Water. Great Western Meter Co.

Measurement of Water. Idaho Bull. 127.

Practical Information on the Measurement of Irrigation Water. Utah Circ. No. 36.

Harper's Hydraulic Tables.

Use of Water in Irrigation. Fortier.

1 U. S. gallon = 231 cubic inches

= 0.13368056 cu. ft.

= 8.3388 lbs.

1 Million gallons = 231,000,000 cu. in.

= 133,680.555 cu. ft.

1 Million gallons per day (24 hours) =

1.54723 cu. ft. per sec.

=

3.0688833 acre feet per 24 hours.

=

1.2787 acre feet per 10 hours.

=

36.82660 acre inches per 24 hours.

* =

15.344 acre inches per 10 hours.

=

694.44 gallons per minute.

=

41,666.66 gallons per hour.

=

416,666.66 gallons per 10 hours.

1 Acre inch = the volume of water that will cover an acre 1 inch deep.

= 6,272,640 cu. in.

= 3,630 cu. ft.

= 27,154.2857 gallons.

= .027,154,285.7 mil. gallons.

1 Acre inch per 10 hours = .108 $\frac{1}{3}$ sec. ft.

1 Acre inch per 24 hours = .042139 sec. ft.

1 Acre foot = volume of water that will cover an acre 1 foot deep.

= 75,271,680 cu. in.

= 43,560 cu. ft.

= 325,851.4286 gals.

= .325,851 + mil. gals.

1 Acre foot per hour = 12.1 sec. ft.

1 Acre foot per 10 hours = 1.21 sec. ft.

1 Acre foot per 24 hours = .5041 $\frac{2}{3}$ sec. ft.

1 Cu. ft. = 7.48051948 gals.

- 1 Cu. ft. water weighs approximately $62\frac{1}{2}$ lbs.
 1 Cu. ft. per sec. = about 1 acre inch per hour.
 (1 sec. ft.) = about 2 acre ft. in 24 hours.
 = 1728 cu. in. per sec.
 = 7.48051948 gals. per sec.
 = .00002295684 acre ft. per sec.
 = 448.83117 gals. per min.
 = .0013774105 acre ft. per min.
 = 26,929.8702 gals. per hour.
 = .082644628 acre ft. per hour.
 = 646,316.88 gals. per day (24 hours).
 = 1.9834711 acre ft. per day (24 hours).
 1 Sec. ft. per 10 hours = 9.917355 acre in.
 = .826446 acre ft.
 1 Sec. ft. per 24 hours = 23.80164 acre in.
 = 1.98347 acre ft.

MAN'S WATER.

There is no established unit to represent the amount of water handled by one man. The term varies on the different plantations and as to whether a man is irrigating in small cane or big cane.

To give an idea of the amount of water passing over a 90° weir or a rectangular weir in terms of man's water, we have chosen two units (a and b) and present the following tables and graphs:

WITH 90° WEIR.

- (a) Where 100,000 gallons per 10 hours = 1 man's water = .371 cu. ft. per sec.

	Cu. Ft. per Sec.	Head in Inches
1 Man's water .....	.371	$5\frac{1}{2}"$
2 Men's " .....	.742	$7\frac{3}{8}"$
3 " "	1.113	$8\frac{5}{8}"$
4 " "	1.484	$9\frac{3}{4}"$
5 " "	1.855	$10\frac{5}{8}"$

- (b) Where 80,000 gallons per 10 hours = 1 man's water = .3 cu. ft. per sec.

	Cu. Ft. per Sec.	Head in Inches
1 Man's water .....	.3	$5\frac{1}{8}"$
2 Men's " .....	.6	$6\frac{13}{16}"$
3 " " .....	.9	$8\frac{13}{16}"$
4 " "	1.2	$8\frac{7}{8}"$
5 " "	1.5	$9\frac{3}{4}"$

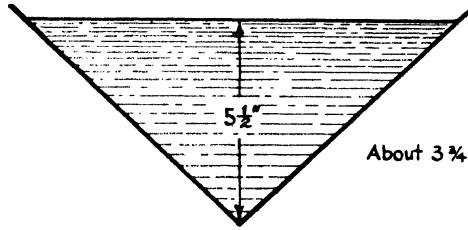
WITH RECTANGULAR WEIR.

- (a) Where 100,000 gallons per 10 hour = 1 man's water = .371 cu. ft. per sec.

		Head in Inches		
	Men's Water	2' Weir	3' Weir	4' Weir
10	Men's water .....	.70	.53	.43
20	" " .....	...	.85	.69
30	" " .....	...	1.10	.92
40	" " .....	...	1.33	1.12
50	" " .....	...	....	1.30

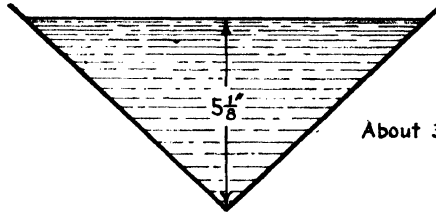
90° V-NOTCH WEIR ONE MAN'S WATER

WHERE 100,000 GALS. PER 10 HOURS = 1 MAN'S WATER (3.71 CU. FT. PER SEC.)



About $3\frac{3}{4}$ Acre Inches

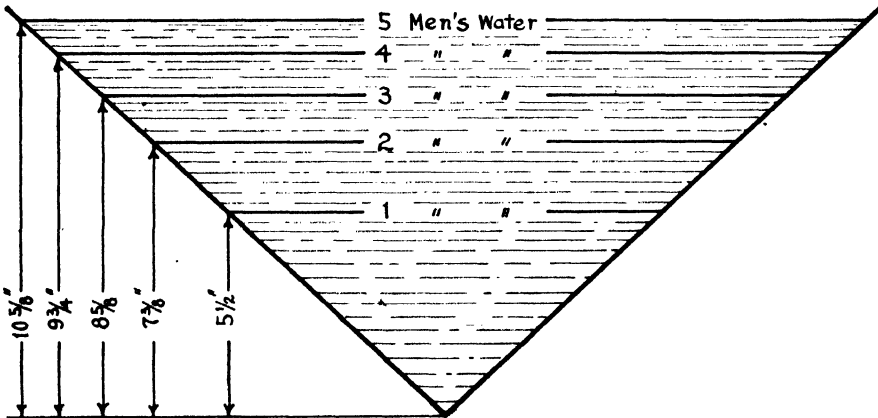
WHERE 80,000 GALS. PER 10 HOURS = 1 MAN'S WATER (3 CU. FT. PER SEC.)



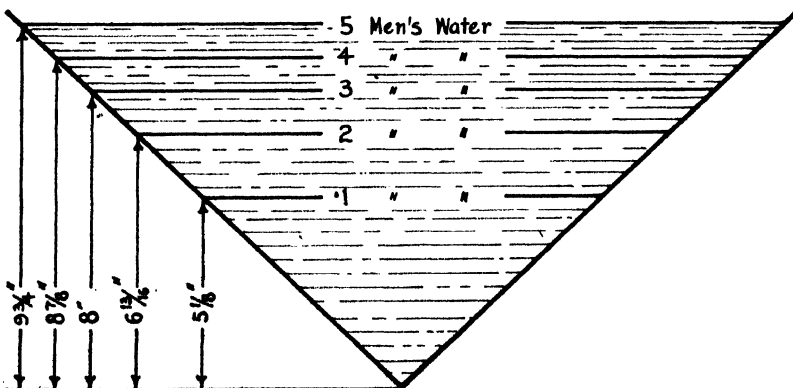
About 3 Acre Inches

ONE TO FIVE MEN'S WATER

WHERE 100,000 GALS. PER 10 HOURS = 1 MAN'S WATER (3.71 CU. FT. PER SEC.)



WHERE 80,000 GALS. PER 10 HOURS = 1 MAN'S WATER (3 CU. FT. PER SEC.)



(b) Where 80,000 gallons per 10 hours = 1 man's water = .3 cu. ft. per sec.

		Head in Inches	
Men's Water		2' Weir	3' Weir
10	Men's water	.62	.46
20	" "	.97	.74
30	" "	...	.98
40	" "	...	1.15
50	" "	...	1.35

CONVERSION TABLE.

Million Gallons To

Million Gals. per 24 Hrs.	U. S. Gals. per Min.	Cu. Ft. * per Sec. for 24 Hrs.	Acre Feet **		Acre Inches ***	
			per 10 Hrs.	per 24 Hrs.	per 10 Hrs.	per 24 Hrs.
1	694.44	1.5472	1.2787	3.06888	15.344	36.8266
2	1,388.88	3.0944	2.5574	6.13777	30.688	73.6532
3	2,083.33	4.6416	3.8361	9.20664	46.032	110.4798
4	2,777.77	6.1888	5.1148	12.2755	61.376	147.3064
5	3,472.22	7.7360	6.3935	15.3444	76.720	184.1330
6	4,166.66	9.2832	7.6722	18.4133	92.064	220.9596
7	4,861.11	10.8304	8.9509	21.4822	107.408	257.7862
8	5,555.55	12.3776	10.2296	24.5310	122.752	294.6128
9	6,249.99	13.9248	11.5083	27.6199	138.096	331.4394
10	6,944.44	15.4720	12.7870	30.6888	153.440	368.2660

* 1 sec. ft. = .646,316.88 mil. gals. ** 1 acre ft. = .325,851 mil. gals. *** 1 acre in. = .027,154 mil. gal.

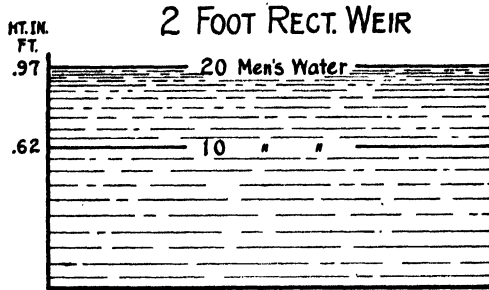
CONVERSION TABLE.

Million Gallons to Acre Feet—1 Million Gallons = 3.0688833 Acre Feet.

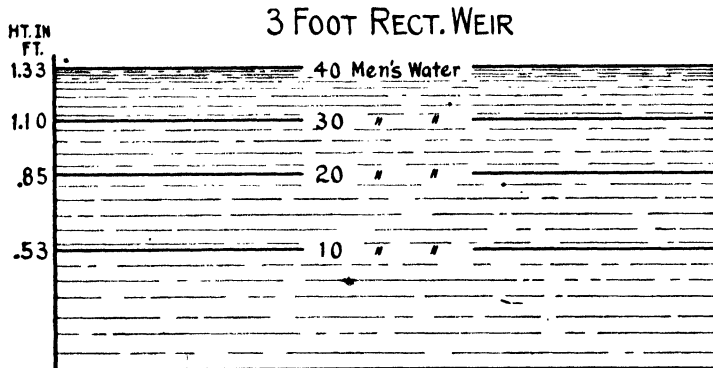
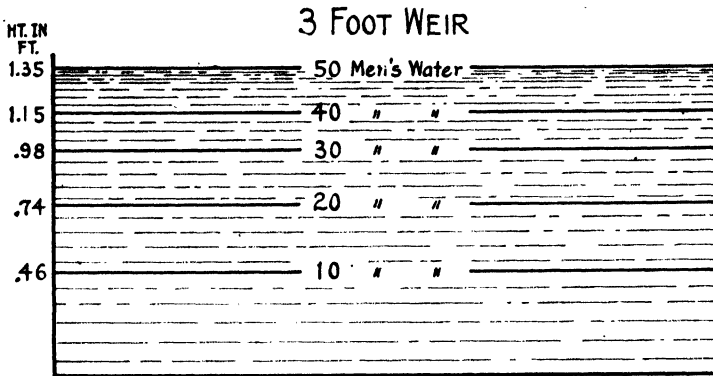
Mil. Gal.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
0	0.00	0.3069	0.6138	0.9207	1.2276	1.5344	1.8413	2.1482	2.4551	2.7620
1	3.0689	3.3758	3.6827	3.9895	4.2964	4.6033	4.9102	5.2171	5.5240	5.8309
2	6.1378	6.4447	6.7515	7.0584	7.3653	7.6722	7.9791	8.2860	8.5929	8.8998
3	9.2066	9.5135	9.8204	10.1273	10.4342	10.7411	11.0480	11.3549	11.6618	11.9686
4	12.2755	12.5824	12.8893	13.1962	13.5031	13.8100	14.1169	14.4238	14.7306	15.0375
5	15.3444	15.6513	15.9582	16.2651	16.5720	16.8789	17.1857	17.4926	17.7995	18.1064
6	18.4133	18.7202	19.0271	19.3339	19.6409	19.9477	20.2546	20.5615	20.8684	21.1753
7	21.4822	21.7891	22.0960	22.4028	22.7097	23.0166	23.3235	23.6304	23.9373	24.2442
8	24.5511	24.8580	25.1648	25.4717	25.7786	26.0855	26.3924	26.6993	27.0062	27.3131
9	27.6199	27.9268	28.2337	28.5406	28.8475	29.1544	29.4613	29.7682	30.0751	30.3819
10	30.6888	30.9957	31.3026	31.6094	31.9164	32.2233	32.5302	32.8371	33.1439	33.4508

Mil. Gal.	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
Acre Ft.	.000	.03069	.06138	.09207	.12276	.15344	.18413	.21482	.24551	.27620

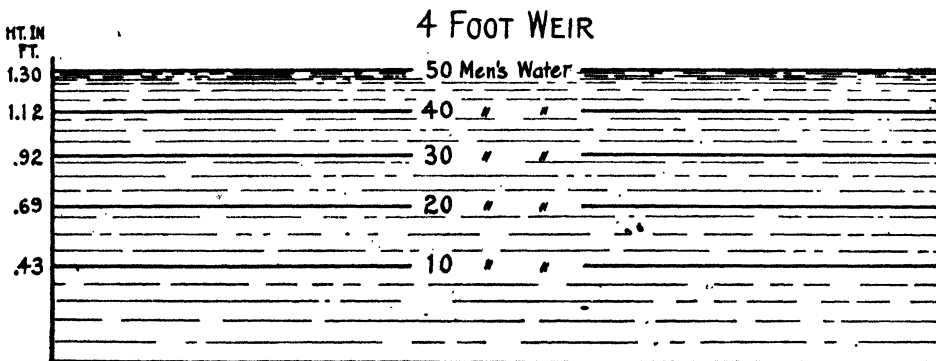
To convert mil. gals. to acre inches multiply by 12.



Where 80,000 Gals.
Per 10 Hours = 1 Man's
Water.



Where 100,000 Gals.
Per 10 Hours = 1 Man's
Water.



CONVERSION TABLE.*

Acre Feet to Million Gallons—1 Acre Foot = .325,851 Million Gallons.

Acre Ft.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
0	.00	.0326	.0652	.0978	.1303	.1629	.1955	.2281	.2607	.2933
1	.3259	.3584	.3910	.4236	.4562	.4888	.5214	.5539	.5865	.6191
2	.6517	.6843	.7169	.7495	.7820	.8146	.8472	.8798	.9124	.9450
3	.9776	1.0101	1.0427	1.0753	1.1079	1.1405	1.1731	1.2056	1.2382	1.2708
4	1.3034	1.3360	1.3686	1.4012	1.4337	1.4663	1.4989	1.5315	1.5641	1.5967
5	1.6293	1.6618	1.6944	1.7270	1.7596	1.7922	1.8248	1.8574	1.8899	1.9225
6	1.9551	1.9877	2.0203	2.0529	2.0854	2.1180	2.1506	2.1832	2.2159	2.2484
7	2.2810	2.3135	2.3461	2.3787	2.4113	2.4439	2.4765	2.5091	2.5416	2.5742
8	2.6068	2.6394	2.6720	2.7047	2.7371	2.7697	2.8023	2.8349	2.8675	2.9001
9	2.9327	2.9652	2.9978	3.0304	3.0630	3.0956	3.1282	3.1608	3.1933	3.2259
10	3.2581	3.2911	3.3237	3.3563	3.3889	3.4214	3.4540	3.4866	3.5192	3.5518

Acre Ft.	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
Mil. Gal.	.000	.00326	.00652	.00978	.01303	.01629	.01955	.02281	.02607	.02933

CONVERSION TABLE.

Second Feet to Acre Feet.

Sec. Ft.	Acre Feet	
	per 10 Hours	per 24 Hours
.01	.00826	.01983
.02	.01653	.03967
.03	.02479	.05950
.04	.03306	.07934
.05	.04132	.09917
.06	.04959	.11901
.07	.05785	.13884
.08	.06612	.15868
.09	.07438	.17851
.10	.08265	.19835

.20	.16529	.39669
.30	.24794	.59504
.40	.33058	.79339
.50	.41322	.99173
.60	.49587	1.19008
.70	.57852	1.38843
.80	.66116	1.58678
.90	.74381	1.78512
1.00	.82645	1.98347

1 sec. ft. per 10 hrs. = .82645 acre ft.

1 sec. ft. per 24 hrs. = 1.98347 acre ft.

* To convert acre inches to million gallons divide by 12 (1 acre inch) = .027,154 million gallons).

CONVERSION TABLE.

Acre Feet to Second Feet.

Acre Ft.	Sec. Ft. per 10 Hours	Sec. Ft. per 24 Hours
.01	.01210	.00504
.02	.02420	.01008
.03	.03630	.01513
.04	.04840	.02017
.05	.06050	.02521
.06	.07260	.03025
.07	.08470	.03529
.08	.09680	.04033
.09	.10890	.04537
.10	.12100	.05042

.2	.2420	.10083
.3	.3630	.15125
.4	.4840	.20167
.5	.6050	.25208
.6	.7260	.30250
.7	.8470	.35292
.8	.9680	.40333
.9	1.0890	.453758
1.00	1.2100	.5041 $\frac{2}{3}$

1 acre ft. per 1 hr. = 12.1 sec. ft.

1 acre ft. per 10 hrs. = 1.21 sec. ft.

1 acre ft. per 24 hrs. = .5041 $\frac{2}{3}$ sec. ft.

CONVERSION TABLE.

Second Feet to Acre Inches.

Sec. Ft.	Acre Inches	
	per 10 Hours	per 24 Hours
.01	.09917	.23802
.02	.19835	.47603
.03	.29752	.71405
.04	.39669	9.5207
.05	.49587	1.19008
.06	.59504	1.42810
.07	.69421	1.66612
.08	.79339	1.90413
.09	.89256	2.14215
.10	.99174	2.38017

.20	1.98347	4.76033
.30	2.97521	7.14050
.40	3.96694	9.52066
.50	4.95868	11.90083
.60	5.95041	14.28100
.70	6.94215	16.66116
.80	7.93388	19.04132
.90	8.92562	21.42149
1.00	9.917355	23.80165

1 sec. ft. per 10 hrs. = 9.917355 acre inches.

1 sec. ft. per 24 hrs. = 23.80165 acre inches.

CONVERSION TABLE.

Acre Inches to Second Feet.

Acre Inches	Second Feet	
	per 10 Hours	per 24 Hours
.01	.00108	.00042
.02	.00217	.00084
.03	.00325	.00126
.04	.00433	.00168
.05	.00542	.00210
.06	.00650	.00252
.07	.00758	.00294
.08	.00867	.00336
.09	.00975	.00378
.10	.01083	.00420
<hr/>		
.2	.02167	.00840
.3	.03250	.01260
.4	.04333	.01681
.5	.05417	.02101
.6	.06500	.02521
.7	.07583	.02941
.8	.08666	.03361
.9	.09750	.03781
1.00	.108 $\frac{1}{4}$	.0420139

1 acre in. per 10 hrs. = .108 $\frac{1}{4}$ sec. ft.

1 acre in. per 24 hrs. = .0420139 sec. ft.

CONVERSION TABLE.

Second Feet per 24 Hours to Million Gallons per Day (24 Hours).

1 Second Foot = 646,316.88 Gallons per Day (24 Hours).

Sec. Ft.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
0	.00	.0646	.1293	.1939	.2585	.3232	.3878	.4524	.5171	.6819
1	0.6463	.7109	.7756	.8402	.9048	.9695	1.0341	1.0987	1.1634	1.2280
2	1.2926	1.3573	1.4219	1.4865	1.5512	1.6158	1.6804	1.7451	1.8097	1.8743
3	1.9390	2.0036	2.0682	2.1328	2.1975	2.2621	2.3267	2.3914	2.4560	2.5206
4	2.5853	2.6499	2.7145	2.7792	2.8438	2.9084	2.9731	3.0377	3.1023	3.1670
5	3.2316	3.2962	3.3608	3.4255	3.4901	3.5547	3.6194	3.6840	3.7486	3.8133
6	3.8779	3.9425	4.0072	4.0718	4.1364	4.2011	4.2657	4.3303	4.3950	4.4596
7	4.5242	4.5888	4.6535	4.7181	4.7827	4.8474	4.9120	4.9766	5.0413	5.1059
8	5.1705	5.2352	5.2998	5.3644	5.4291	5.4937	5.5583	5.6230	5.6876	5.7522
9	5.8169	5.8815	5.9461	6.0107	6.0754	6.1400	6.2046	6.2693	6.3339	6.3985
10	6.4632	6.5278	6.5924	6.6571	6.7217	6.7863	6.8510	6.9156	6.9802	7.0449
<hr/>										
Sec. Ft.	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
Mil. Gal.	.000	.0065	.0129	.0194	.0259	.0323	.0388	.0452	.0517	.0582

DISCHARGE TABLE FOR 90° TRIANGULAR NOTCH WEIR.
From the Formula $Q = 2.49 H^{3/2}$.

Head in Feet	Head in Inches	Discharge in Second Feet (Q)	Head in Feet	Head in Inches	Discharge in Second Feet (Q)
.20	2 3/8	.046	.70	8 3/8	1.03
.21	2 1/2	.052	.71	8 1/2	1.06
.22	2 5/8	.058	.72	8 5/8	1.10
.23	2 3/4	.065	.73	8 3/4	1.14
.24	2 7/8	.072	.74	8 7/8	1.18
.25	3	.080	.75	9	1.22
.26	3 1/8	.088	.76	9 1/8	1.26
.27	3 1/4	.096	.77	9 1/4	1.30
.28	3 3/8	.106	.78	9 3/8	1.34
.29	3 1/2	.115	.79	9 1/2	1.39
.30	3 5/8	.125	.80	9 5/8	1.43
.31	3 3/4	.136	.81	9 3/4	1.48
.32	3 13/16	.147	.82	9 13/16	1.52
.33	3 15/16	.159	.83	9 15/16	1.57
.34	4 1/16	.171	.84	10 1/16	1.61
.35	4 3/16	.184	.85	10 3/16	1.66
.36	4 5/16	.197	.86	10 5/16	1.71
.37	4 7/16	.211	.87	10 7/16	1.76
.38	4 9/16	.226	.88	10 9/16	1.81
.39	4 11/16	.240	.89	10 11/16	1.86
.40	4 13/16	.256	.90	10 13/16	1.92
.41	4 15/16	.272	.91	10 15/16	1.97
.42	5 1/16	.289	.92	11 1/16	2.02
.43	5 3/16	.306	.93	11 3/16	2.08
.44	5 1/4	.324	.94	11 1/4	2.13
.45	5 3/8	.343	.95	11 3/8	2.19
.46	5 1/2	.362	.96	11 1/2	2.25
.47	5 5/8	.382	.97	11 5/8	2.31
.48	5 3/4	.403	.98	11 3/4	2.37
.49	5 7/8	.424	.99	11 7/8	2.43
.50	6	.445	1.00	12	2.49
.51	6 1/8	.468	1.01	12 1/8	2.55
.52	6 1/4	.491	1.02	12 1/4	2.61
.53	6 3/8	.515	1.03	12 3/8	2.68
.54	6 1/2	.539	1.04	12 1/2	2.74
.55	6 5/8	.564	1.05	12 5/8	2.81
.56	6 3/4	.590	1.06	12 3/4	2.87
.57	6 13/16	.617	1.07	12 13/16	2.94
.58	6 15/16	.644	1.08	12 15/16	3.01
.59	7 1/16	.672	1.09	13 1/16	3.08
.60	7 3/16	.700	1.10	13 3/16	3.15
.61	7 5/16	.730	1.15	13 5/16	3.22
.62	7 7/16	.760	1.20	13 7/16	3.31
.63	7 9/16	.790	1.25	14	3.43
.64	7 11/16	.822			
.65	7 13/16	.854			
.66	7 15/16	.887			
.67	8 1/16	.921			
.68	8 3/16	.955			
.69	8 1/4	.991			

DISCHARGE OF RECTANGULAR CONTRACTED WEIRS IN SECOND FEET.

Length of Weir in Feet.

Compiled from "Measurement of Water," U. S. Reclamation Service, 1923.

H. D.	1.	1.5	2.	3.	4.	5.	6.	7.	8.	9.
.10	.103	.156	.208	.314	.419	.524	.630	.735	.840	.945
.12	.135	.204	.273	.412	.550	.689	.827	.965	1.10	1.24
.14	.169	.257	.344	.518	.693	.867	1.04	1.22	1.39	1.56
.16	.206	.313	.419	.632	.845	1.06	1.27	1.48	1.70	1.91
.18	.245	.372	.499	.754	1.01	1.26	1.52	1.77	2.02	2.28
.20	.286	.435	.584	.881	1.18	1.48	1.78	2.07	2.37	2.67
.22	.328	.500	.672	1.02	1.36	1.70	2.05	2.39	2.73	3.08
.24	.373	.568	.764	1.16	1.55	1.94	2.33	2.72	3.11	3.50
.26	.419	.639	.860	1.30	1.74	2.18	2.63	3.07	3.51	3.95
.28	.466	.712	.959	1.45	1.95	2.44	2.93	3.43	3.92	4.41
.30	.514	.788	1.06	1.61	2.16	2.70	3.25	3.80	4.34	4.89
.32	.564	.866	1.17	1.77	2.37	2.98	3.58	4.18	4.78	5.39
.34	.615	.945	1.28	1.94	2.60	3.26	3.92	4.58	5.24	5.90
.36	.686	1.03	1.39	2.11	2.82	3.54	4.26	4.98	5.70	6.42
.38	.743	1.11	1.50	2.28	3.06	3.84	4.62	5.40	6.18	6.96
.40	.801	1.20	1.62	2.46	3.30	4.14	4.99	5.83	6.67	7.51
.42	.860	1.28	1.74	2.64	3.55	4.46	5.36	6.27	7.18	8.08
.44	.920	1.37	1.86	2.83	3.80	4.77	5.75	6.72	7.69	8.66
.46	.981	1.46	1.98	3.02	4.06	5.10	6.14	7.18	8.22	9.26
.48	1.04	1.56	2.11	3.22	4.32	5.43	6.54	7.64	8.75	9.86
.50	1.11	1.65	2.24	3.41	4.59	5.77	6.95	8.12	9.30	10.48
.52	.....	1.74	2.37	3.62	4.86	6.11	7.36	8.61	9.86	11.1
.54	.....	1.84	2.50	3.82	5.14	6.46	7.79	9.11	10.4	11.8
.56	.....	1.94	2.64	4.03	5.43	6.82	8.22	9.61	11.0	12.4
.58	.....	2.04	2.77	4.24	5.71	7.18	8.66	10.1	11.6	13.1
.60	.....	2.14	2.91	4.46	6.00	7.55	9.10	10.6	12.2	13.7
.62	.....	2.24	3.05	4.68	6.30	7.93	9.55	11.2	12.8	14.4
.64	.....	2.34	3.19	4.90	6.60	8.31	10.0	11.7	13.4	15.1
.66	.....	2.44	3.34	5.12	6.91	8.69	10.5	12.3	14.0	15.8
.68	.....	2.55	3.58	5.35	7.22	9.08	11.0	12.8	14.7	16.6
.70	.....	2.65	3.74	5.58	7.53	9.48	11.4	13.4	15.3	17.3
.72	.....	2.76	3.90	5.81	7.84	9.88	11.9	13.9	16.0	18.0
.74	.....	2.87	4.06	6.05	8.16	10.3	12.4	14.5	16.6	18.8
.76	.....	.....	4.22	6.28	8.49	10.7	12.9	15.1	17.3	19.5
.78	.....	.....	4.38	6.52	8.82	11.1	13.4	15.7	18.0	20.3
.80	.....	.....	4.54	6.77	9.15	11.5	13.9	16.3	18.7	21.1
.82	.....	.....	4.70	7.01	9.48	12.0	14.4	16.9	19.4	21.8
.84	.....	.....	4.87	7.26	9.82	12.4	15.0	17.5	20.1	22.6
.86	.....	.....	5.05	7.51	10.2	12.8	15.5	18.1	20.8	23.4
.88	.....	.....	5.23	7.76	10.5	13.3	16.0	18.8	21.5	24.3
.90	.....	.....	5.41	8.02	10.9	13.7	16.5	19.4	22.2	25.1
.92	.....	.....	5.59	8.28	11.2	14.2	17.1	20.0	23.0	25.9
.94	.....	.....	5.77	8.53	11.6	14.6	17.6	20.7	23.7	26.7
.96	.....	.....	5.95	8.80	11.9	15.1	18.2	21.3	24.5	27.6
.98	.....	.....	6.13	9.06	12.3	15.5	18.8	22.0	25.2	28.4
1.00	.....	.....	6.31	9.32	12.7	16.0	19.3	22.6	26.0	29.3

Cutting Back Experiments at Ewa Plantation

By W. P. ALEXANDER

The practice of the "cutting back" of H 109 young ratoon cane in July on the lands of the Ewa Plantation Company not only brings no benefit to the growing crop, but there may be also a definite loss in tonnage of cane and sugar when this procedure is followed. Such is the conclusion reached, after harvesting five well laid out and carefully conducted experiments for the 1923 crop. There was practically no tasseling of the cane in any of the experiments.

A gain of 1.08 tons of sugar per acre was secured by not cutting back, being the result of the additional 7.45 tons of cane per acre. The above figures are the averaged yields of the five tests. These tests covered five typically different locations on the plantation with varying conditions of drainage, slope and character of soil.

The saving of labor was an extra advantage. This was effected in two ways:

- (1) No labor used in the operation of cutting back.
- (2) Less labor used in hoeing as the result of the quicker closing in of the non-cut-back cane, thus shading out the weeds.

The cane yields are briefly tabulated below:

Field	Character of Field	Tons of Cane per Acre	
		Non-cut-back	Cut-back
AS 2	Deep soil, steep slope.....	111.37	97.39
1-C	Shallow soil, steep slope.....	96.38	88.73
1-A	Deep soil, level.....	82.96	83.66
10-A	Deep soil, level.....	128.42	122.28
19-B	Deep soil, level.....	94.91	88.03
	Average	101.53	94.08

Gain for non-cut-back, 7.45 tons cane per acre.

The experiments vary in the gain of the check plots over the plots cut back. In Field Apokaa 2, there was an average gain of practically 13 tons cane per acre; in Field 1-C a gain of 7.65 tons cane per acre; in 10-A a gain of 6.14 tons cane and 19-B a gain of 6.88 tons cane, while in Field 1-A, the yields for all practical purposes were the same.

Four experiments gave the following average increase in tons sugar per acre:

Field AS 2.....	1.99 tons sugar per acre
" 10-A	1.13 " " " "
" 19-B	1.12 " " " "
" 1-C .....	.77 " " " "
Average of four tests.....	1.43 " " " "

The fifth experiment in Field 1-A gave no gain, and discounting the extra poor juices in Plot 8-X, there would be no loss either.

In three cases, the plots where no cutting back was practiced, averaged better juices; in one case average juice was about the same, and in one case poorer for the non-cut-back plots.

The above summarizes the data secured in a general way. A more detailed analysis of the cane and sugar yields of the harvesting figures from the five experiments follows:

APOKAA 2 (H 109) SUMMARY AVERAGE YIELDS.

	Area	No. of Plots	Cane	Quality Ratio	Sugar
Non-cut-back .....	.702	6	111.37	7.88	14.13
Cut-back .....	.658	6	97.38	8.02	12.14
Loss for cutting back.....			13.99	.14	1.99

This test was located on a steep slope on a portion of the field that dried out very quickly. It is here that tasseling, if any, would be heaviest. The previous crop was harvested May 10 to 25, and the ratoons were not irrigated until after cutting back on July 7, 1921. Six hundred and forty-five lbs. per acre of nitrate of soda, equivalent to 100 lbs. of nitrogen, were applied to all plots on September 8-10, 1921. The experiment was irrigated about every 18 days. There was practically no tasseling during the winter and the greater growth in the non-cut-back plots showed up when the cane was six months old. The field was badly infested with nut grass. On March 15, 1922, ammonium nitrate was applied in the irrigation water at the rate of 500 lbs. per acre.

Plot yields charted in Fig. 1 are very consistently in favor of the non-cut-back plots. The exception, plot 10-C, is at the point where there is constant seepage from a pump discharge.

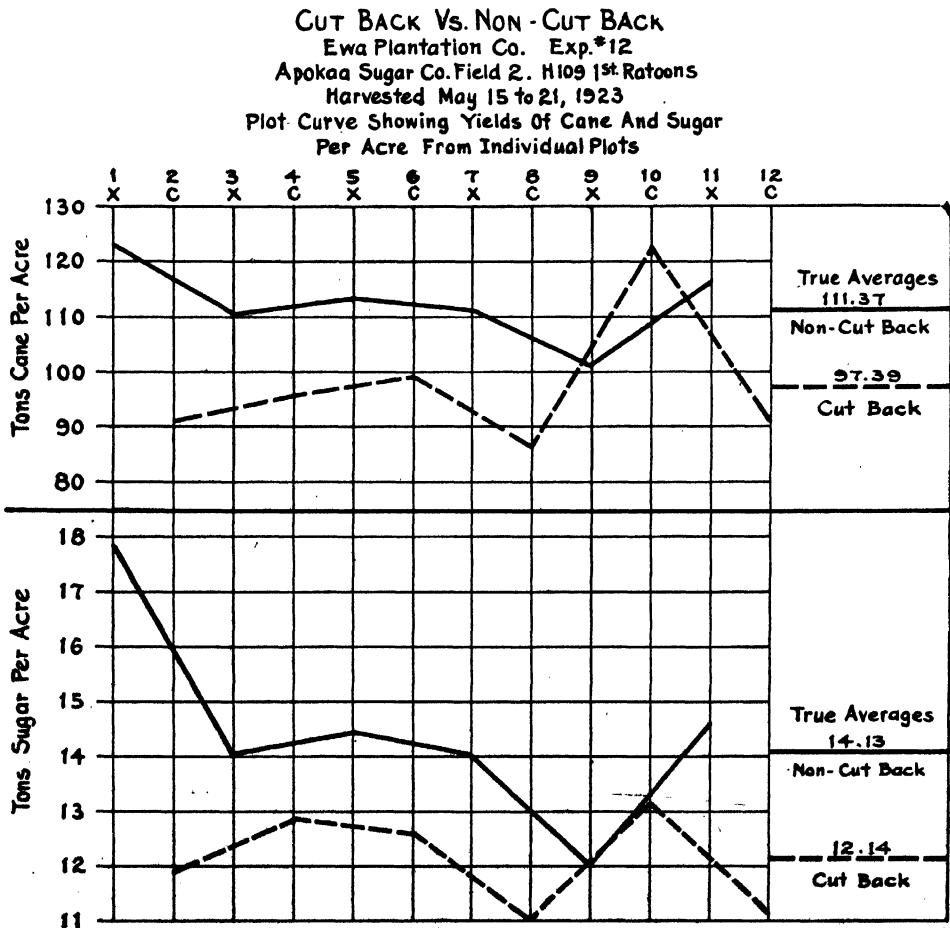


Fig. 1.

TABLE 1.

EWA PLANTATION CO.

Field AS 2 Cut-Back vs. Non-Cut-Back Experiment.

Harvested May 16-21, 1923.

Summary of Results.

Non-Cut-Back

			Tons Cane	Tons Cane	Tons Sugar	Tons Sugar	Quality	Poi. %			
Plot	Treatment	Area	Total	per Acre	Total	per Acre	Ratio	Cane	Brix	Pol.	Purity
1	Non-Cut-Back	0.047	5.7895	123.18	0.83906	17.85	6.90	15.42	20.40	18.80	92.16
3	“	0.143	15.7840	110.38	2.0133	14.08	7.84	13.86	18.90	16.90	89.42
5	“	0.138	15.6910	113.70	1.9938	14.45	7.87	13.94	19.30	17.00	88.08
7	“	0.125	13.9200	111.36	1.7553	14.04	7.93	13.86	19.20	16.90	88.02
9	“	0.116	11.7540	101.33	1.3960	12.03	8.42	13.20	18.60	16.10	86.56
11	“	0.089	10.3410	116.19	1.30075	14.615	7.95	13.78	19.00	16.80	88.42
True Averages		0.658	73.2795	111.37	9.2994	14.13	7.88	13.88	19.13	16.93	88.50

Cut-Back

2	Cut-Back	0.142	12.9215	91.00	1.6957	11.94	7.62	14.19	19.20	17.30	90.10
4	“	0.126	12.1005	96.04	1.6242	12.89	7.45	14.43	19.40	17.60	90.72
6	“	0.122	12.1090	99.25	1.5386	12.61	7.87	13.94	19.30	17.00	88.08
8	“	0.138	11.9620	86.68	1.5180	11.00	7.88	14.02	19.60	17.10	87.24
10	“	0.106	13.0425	123.04	1.3949	13.16	9.35	12.05	17.30	14.70	84.97
12	“	0.068	6.2330	91.66	0.7564	11.12	8.24	13.61	19.40	16.60	85.57
True Averages.....		0.702	68.3685	97.39	8.52475	12.14	8.02	13.69	18.98	16.70	87.99

FIELD 1-C (H 109) SUMMARY AVERAGE YIELDS.

	Area	No. of Plots	Cane	Quality Ratio	Sugar
Cut-back	1.089	4	88.73	8.81	10.07
Non-cut-back		4	96.38	8.89	10.84
Loss for cutting back.....			7.65	.08	.77

On a well drained pali slope the site for this experiment was chosen because it is here that tasseling is usually heaviest. The previous crop was harvested on March 25, 1921, and until the cane was cut back on July 6, 1921, the irrigation was not regular. It consisted of two or three rounds; just enough to keep the cane from dying out. Thereafter, irrigation was steady at between 15- and 20-day intervals. Even so, the leaves would often be curled before applying water. Fertilizer was applied on August 18, 1921, at the rate of 645 lbs. of nitrate of soda per acre. An excessive amount of weed growth appeared in the plots which had been cut back. Actual timing showed 77.5 per cent more labor required to hoe these plots over the non-cut-back plots. Tassels were almost a minus quantity. Plot 2 had 9; plot 4 had 3; and plot 6 had 2; otherwise there were none at all. The stalks in the non-cut-back plots appeared larger and longer than those in the cut-back plots. There were more stalks, however, in the latter plots.

Table 2 gives the detailed harvesting data for each plot. With the exception of plot 5, which is in more of a hollow, every check plot gave a higher yield than the cut-back plot adjoining. The average cane yields showed a gain of 9.68 tons of cane per acre where no cutting back was practiced. Plot 1 (cut-back) was exposed and poorly situated as regards fertility. It should be discarded. The average cane yield per acre then becomes 88.73 tons as against 86.70 tons, and the gain is reduced to 7.65 tons of cane per acre.

The quality of the juice varied from plot to plot, but averaging all plots was practically identical for cut-back and non-cut-back plots.

TABLE 2.

Field 1-C Cut-Back Experiment.

Harvesting Results—January 24, 1923.

Summary of Results.

Plot	Treatment	Area	Total	Tons Cane	Tons Sugar	Quality			
			Tons Cane	per Acre	per Acre	Ratio	Brix	Pol'n	Purity
1	Cut-Back ..	0.151	11.97	79.27	9.61	8.25	18.6	16.3	87.6
3	“ ..	0.096	10.0225	104.40	11.26	9.27	18.2	15.1	83.0
5	“ ..	0.143	13.73	96.01	10.87	8.83	18.1	15.5	85.6
7	“ ..	0.153	12.6625	82.76	9.83	8.42	18.6	16.1	86.6
9	“ ..	0.157	12.30	78.34	8.81	8.89	18.0	15.4	85.6
True Averages...		0.700	60.6850	86.70	9.98	8.69	18.30	15.7	85.79
Omitting Plot 1		0.549	48.715	88.73	10.07	8.81	18.23	15.55	85.30
2	Non-Cut-Back	0.122	12.385	101.52	11.78	8.62	18.4	15.8	85.9
4	“	0.121	12.945	106.98	12.17	8.79	18.0	15.5	86.1
6	“	0.151	13.5825	89.95	10.47	8.59	18.8	16.0	85.1
8	“	0.146	13.135	89.97	9.34	9.63	17.1	14.4	84.2
True Averages...		0.540	52.0475	96.38	10.84	8.89	18.08	15.42	85.29

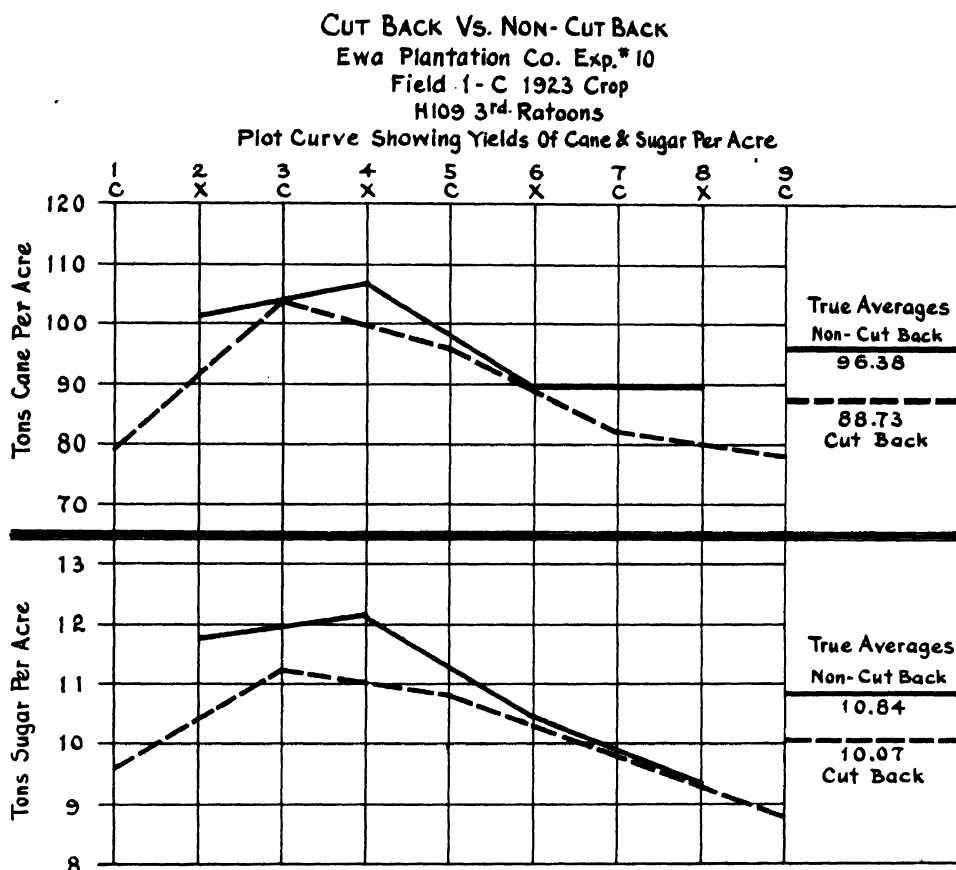


Fig. 2.

FIELD 1-A (H 109) SUMMARY AVERAGE YIELDS.

	Area	No. of Plots	Cane	Quality Ratio	Sugar
Cut-back	1.352	4	83.66	8.00	10.46
Non-cut-back	1.406	4	82.96	8.17	10.15
Gain for cut-back plots.....			.70	.17	.31

The average yields of cane per acre are very close. The sucrose content being lower in the non-cut-back plots, due principally to the poorer quality of Plot 8-X, the yields of sugar when averaged slightly favor the cut-back plots.

When the crop started the non-cut-back plots led those which had been cut back in height of cane. The inference would be, therefore, that cutting back induced more stooling which compensated for the loss in length of stalk.

The previous crop was harvested May 4, 1921, and the new ratoons were cut back on July 5, 1922. Weed growth was nil in the non-cut-back plots, although not very great in the adjacent cut-back plots. On August 23, the experiment received uniformly to all plots 645 lbs. of nitrate of soda per acre.

Field was irrigated at about 30-day intervals. On October 3, 1921, there was a heavy rain. The only tasseling in the experiment was along the ditch in the non-cut-back plots. On March 30, 1922, the entire experiment received 500 lbs. of ammonium nitrate in the irrigation water.

Field 1-A has fair slope with a well drained deep soil.

TABLE 3.

EWA PLANTATION COMPANY.

Field 1-A Cut-Back Experiment.

Date Harvested, January 27 to 29, 1923.

Summary of Results.

Plot	Treatment	Area	Total	Tons	Total	Tons Sugar	Quality		Pol.	Purity	Grams P ₂ O ₅
			Tons Cane	per Acre	Tons Sugar	per Acre	Ratio	Brix			in 100 cc Juice
1	Cut-back	0.216	17.7075	81.98	2.267	10.50	7.81	19.10	17.00	89.00	0.048
3	"	0.379	29.5525	77.97	3.736	9.86	7.91	19.70	17.10	86.80	0.046
5	"	0.432	37.0000	85.65	4.7375	10.97	7.81	19.10	17.00	89.00	0.038
7	"	0.325	28.8525	88.78	3.394	10.44	8.50	18.30	15.90	86.89	0.029
True Averages		1.352	113.1125	83.66	14.139	10.46	8.00	19.05	16.75	87.93	0.036
2	Non-cut-back	0.290	21.9275	75.61	2.874	9.91	7.63	19.80	17.5	88.38	0.036
4	"	0.399	30.6125	76.72	3.996	10.02	7.66	19.90	17.5	87.94	0.038
6	"	0.404	34.240	84.75	3.981	9.85	8.60	18.30	15.8	86.34	0.029
8	"	0.313	29.855	95.38	3.4316	10.96	8.70	17.90	15.55	86.87	0.024
True Averages		1.406	116.635	82.96	14.276	10.15	8.17	18.90	16.50	87.30	0.031

FIELD 10-A (H 109) SUMMARY COUNTS AND AVERAGE YIELDS PER FOOT.

	Area	No. of Plots	Shoots Age 7 & 6 Mo.	Stalks at Harvest	Avg. Cir- cumference*	Average Yields		
						Cane	Q. R.	Sugar
Non-cut-back .....	.28	3	4.49	2.6082	.3632	128.42	8.36	15.36
Cut-back .....	.35	4	5.83	2.7325	.3494	122.28	8.59	14.23
Loss for cutting back						6.14	.23	1.13

* Average 800 stalks.

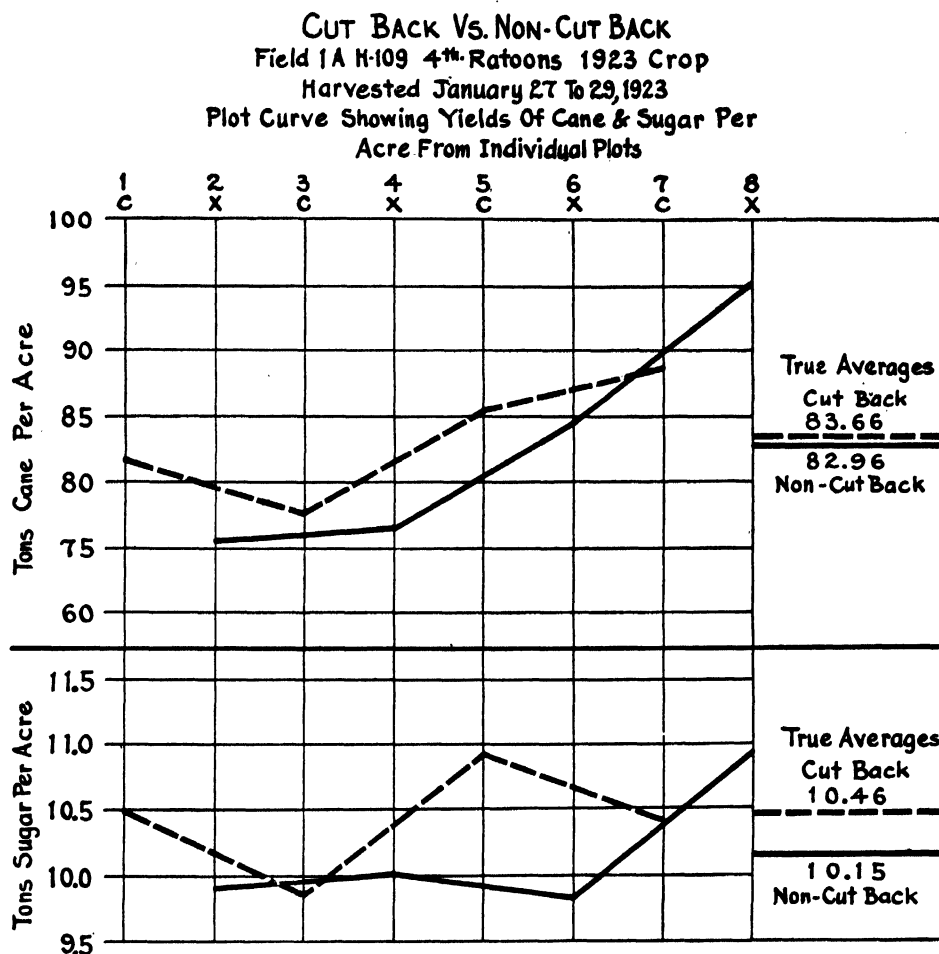


Fig. 3.

The loss for cutting back as shown by these average figures is corroborated by comparing the individual plot yields as shown by the plot curve (Fig. 4). There is no question about the increased yields due to non-cutting back.

While the stalks are very slightly larger in circumference for the non-cut-back plots, there are almost 5 per cent less stalks. The conclusion drawn is that longer stalks are responsible for increased yield. It is interesting to note that cutting back stimulated a great many shoots which were unable to continue growth so as to form stalk of cane which could be harvested. There was some mortality of shoots in the non-cut-back plots, but not as great as in the cut-back plots.

The quality ratio is consistently better for the cane that was not cut back, i. e., the older the cane the better the juice.

The previous crop was harvested on May 23, 1921, and the experiment was milled March 15, 1923. The alternate plots were cut back on July 6, 1921, and irrigated thereafter every 20 days. Weed growth immediately began to be very bad in the plots which were cut back. It required 36.3 per cent more labor to weed these plots as compared with the non-cut-back plots.

On August 19, 1921, the entire experiment received 645 lbs of nitrate of soda per acre (100 lbs. N.). On October 3, 1921, there was a 3-inch rain.

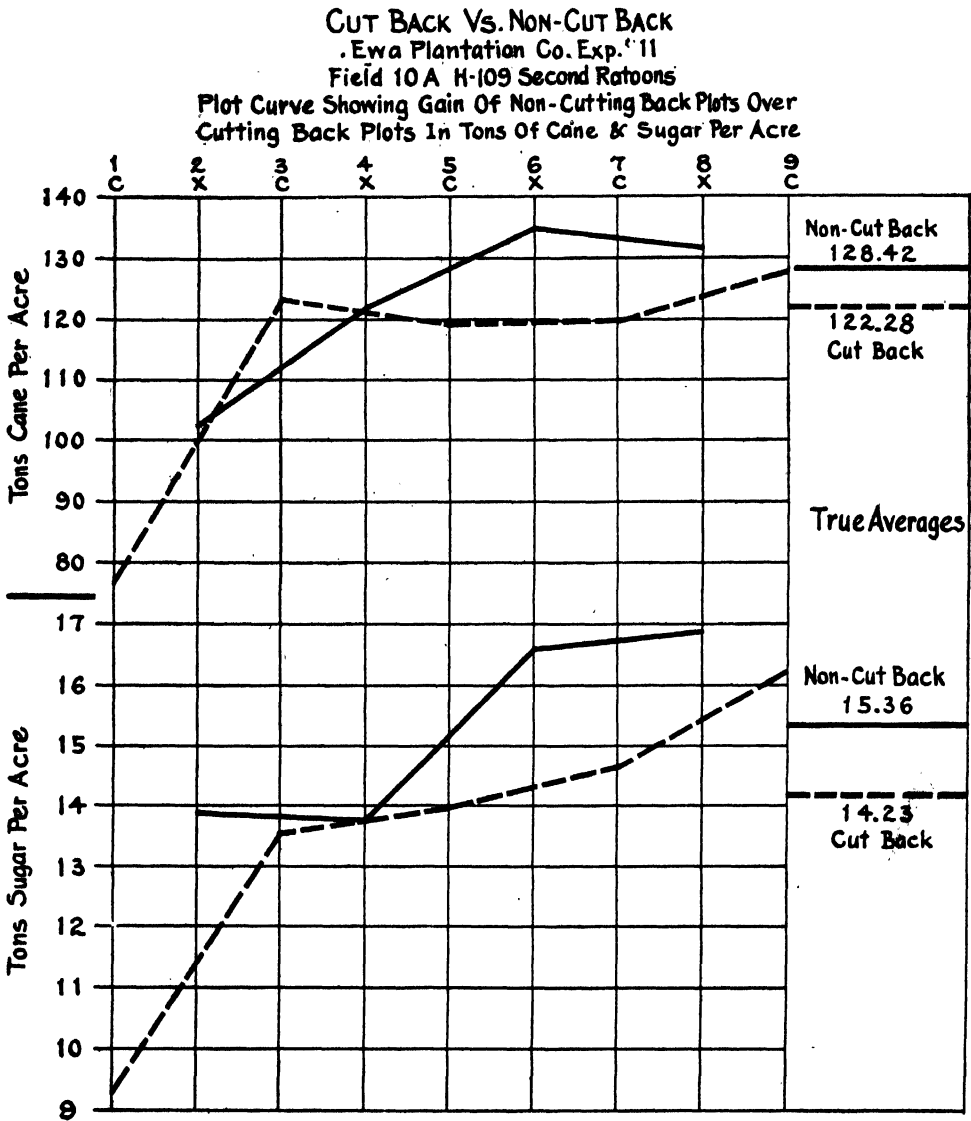


Fig. 4.

Not a single tassel appeared in either plots. Cane was growing very vigorously in the entire experiment, but in November it was noted that the cut-back plots contained a thicker growth than non-cut-back plots, although the cane was at least a foot higher in the check plots. Counts at this time showed almost 30 per cent more shoots or 50,791 shoots per acre in cut-back plots, as against 39,116 per acre in X plots. This extra growth did not reach maturity.

At harvest, trash on the ground was heavier on the cut-back plots, partly accounted for by the shoots that did not survive. The 30 per cent lead was cut down to one of less than 5 per cent, i. e., the cut-back plots had 23,805 stalks per acre as compared with 22,722 stalks in non-cut-back plots.

A second dose of 645 lbs. nitrate of soda per acre was made on March 1, 1922 (total 200 lbs. N.). Cane in both sets of plots made a splendid growth during the second season.

TABLE 4.

EWA PLANTATION COMPANY.

Field 10-A Cut-Back Experiment.

Harvesting Results, March 15, 1923. (Previous Crop Harvested May 23, 1921.)

Summary of Results.

Cut-Back

Plot	Treatment	Area	Tons Cane		Total Tons Sugar	Tons Sugar per Acre	Pol. %							Remarks
			Total	per Acre			Q.R.	Cane	Brix	Pol'n	Purity	P ₂ O ₅	K ₂ O	
1	Cut-back	.096	7.3845	76.92	0.89	9.27	8.30	13.28	18.5	16.2	87.6	0.040	0.066	Ditch plot
3	"	.138	17.0675	123.68	1.876	13.59	9.10	12.22	17.2	14.9	86.6	0.040	0.091	
5	"	.108	12.929	119.71	1.512	14.00	8.55	12.79	17.6	15.6	88.6	0.030	0.093	Stand very
7	"	.066	7.9205	120.01	0.969	14.68	8.17	13.28	18.1	16.2	89.5	0.037	0.093	poor
9	"	.041	5.2465	127.96	0.667	16.27	7.86	13.78	18.7	16.8	89.8	0.032	0.074	
True Averages.....		.367	44.781	122.02	5.919	13.18	8.54	12.85	17.79	15.67	88.08	0.0358	0.083	
Omitting Plot 1.....		0.353	43.1635	122.28	5.025	14.23	8.59	12.78	17.67	15.58	88.17	0.0348	0.0878	

Non-Cut-Back

2	Non-cut-back	.091	9.337	102.60	1.267	13.92	7.37	14.51	19.3	17.7	91.6	0.045	0.056	Irregular
4	"	.129	15.745	122.05	1.783	13.82	8.83	12.55	17.6	15.3	86.9	0.035	0.109	plot
6	"	.089	12.023	135.09	1.477	16.59	8.14	13.28	18.0	16.2	89.9	0.035	0.113	
8	"	.058	7.676	132.34	0.98	16.90	7.83	13.78	18.6	16.8	90.3	0.032	0.126	
True Averages.....		.367	44.781	122.02	5.508	15.01	8.13	13.37	18.23	16.30	89.41	0.0368	0.101	
Omitting Plot 2.....		.276	35.444	128.42	4.24	15.36	8.36	13.06	17.95	15.93	88.75	0.034	0.116	

**FIELD 19-B (H 109) SUMMARY AVERAGE YIELDS LAHAINA WITH H 109
REPLANT.**

	Area	No. of Plots	Average Yields per Acre		
			Cane	Quality Ratio	Sugar
Cut-back	{	5	88.03	7.94	11.09
Non-cut-back	}	5	94.91	7.77	12.21
Loss for cutting back.....			6.88	.17	1.12

This test of old Lahaina ratoons, largely replanted with H 109, was small in total area, consisting of 10 plots of 8 lines (35 feet) each. Alternate plots were not cut back on July 8, 1921. The field had been harvested May 4, 1921, but had received practically no attention until after cutting back on August 8, 1921. All plots received 645 lbs. per acre of nitrate of soda. Rounds were about 25 days apart. There was no tasseling in the non-cut-back plots during the flowering season. The check plots at this time seemed to have a better growth than the cut-back plots. Plot yields are given in Table 5. While not consistently favoring non-cut-back, the general tendency is for better cane yields for the non-cut-back plots from 2 out of 3 plots.

There was made a composite cane sample in carload lots for each treatment and crusher juice of all plots obtained. The non-cut-back gave a quality ratio that was 2.26 per cent better.

The final gain in sugar produced, averaging all plots, therefore, was 10 per cent better for the plots that were not cut-back.

TABLE 5.

EWA PLANTATION COMPANY.

Field 19-B Cut-Back Experiment

Harvesting Results, December 23, 1922.

Cut-Back.

Plot	Area	Total Cane	Cane per Acre	Sugar per Acre	Quality Ratio	Brix	Pol.	Purity
1	.037	3.08	83.24	Composited				
3	.025	2.2975	91.90					
5	.029	2.1725	74.91					
7	.029	2.490	85.86					
9	.030	3.165	105.50					
	.150	13.205	88.03	11.09	7.94	20.4	17.3	84.8

Non-Cut-Back.

2	.028	2.4225	86.52	Composited				
4	.025	2.23	89.20					
6	.026	2.195	84.42					
8	.031	3.3725	108.79					
10	.029	2.9725	102.50					
	.139	13.1925	94.91	12.21	7.77	20.6	17.6	85.4

Lupines for Green Manuring

HAMAKUA MILL EXPERIMENT 11, 1923 CROP.

By J. A. VERRET

Lupines (*Lupinus albus*) have been grown to some extent on the island of Hawaii as a green manuring crop. Of the cultivated legumes it is among those which make the best growth on that island. It has no value as a food crop, so its place in the agriculture of Hawaii would depend on its worth as a soil renovator.

ITALIAN LUPINES VS. NATURAL FALLOW

Hamakua Mill Co. Exp. 11, 1923 Crop

Field 17 A.

Hilo Side	Fence			Road	Hamakua Side
	1	A	49.2		
	2	B	44.3		
	3	A	45.0		
	4	B	52.2		
	5	A	45.4		
	6	B	50.8		
	7	A	48.0		
	8	B	44.7		
	9	A	45.8		
	10	B	50.9		
	11	A	45.9		
	12	B	43.2		
	13	A	55.1		
	14	B	50.0		
	15	A	39.5		
	16	B	42.9		
	17	A	51.8		
Field					

Summary of Results

Plots	No. of Plots	Treatment	Yields Per Acre		
			Cane	Q.R.	Sugar
A	9	Lupine	47.28	7.36	6.42
B	8	No Lupine	47.34	7.32	6.46

In order to get information upon this point an experiment was laid out at Hamakua Mill Co. The test comprised seventeen plots, each one-sixth acre, consisting of eight lines, 5 feet wide and 181.5 feet long. Nine plots were planted to lupines and eight were allowed to remain in natural fallow.

The lupines were planted in November, 1920, and came up well. On January 10, 1921, they were from 6 to 9 inches high. At that time the check plots had a light growth of pualele and oxalis. An examination of the lupine roots showed them well covered with nitrogen nodules. No nematode galls were found on the roots examined.

The lupines were plowed in on April 18, 1921. At that time they were about three feet high. Very few of the plants had flowered, as caterpillars got at them before they had a full chance to flower. The lupines in plots 1, 3 and 5 were practically dead, as the leaves had been eaten off.



Italian lupines growing at Pahala—three months old. (Photo by Hawaiian Agricultural Company.)

Weeds were not very thick in the no-lupine plots. When plowing in the lupines the other plots were also given the same treatment so as to eliminate cultivation as a factor in the results. The lupines were well covered.

The field was furrowed June 10, 1921, and planted to Yellow Caledonia June 11. At the time of furrowing the lupines had not completely rotted and a few of the larger stalks were pulled up. But this was only a small percentage of the total amount buried. All plots received uniform fertilization according to plantation practice for plant cane.

The experiment was harvested July 12, 1923. The juices were sampled by Mr. Murray in carload lots.

The results show no advantage for the lupine plots, as indicated below :

Treatment	Yield per Acre		
	Cane	Q. R.	Sugar
Lupines	47.3	7.36	6.42
No lupines	47.3	7.32	6.46

The Station does not advocate the use of lupines for green manuring purposes. We believe it is more profitable to the plantations to allow natural growth to take place on the fallow fields and to pasture stock on them. This entails no expense and furnishes feed for cattle and gets some benefit from the manure produced.

The above test will be continued for another crop to note if there is any residual or delayed action from the material plowed under.

DETAILS OF EXPERIMENT

Green Soiling

Object—

Comparing legumes with no legumes.
The legume was Italian Lupines (*Lupinus albus*).

Location—

Hamakua Mill Company, Field 17-A.

Crop—

Yellow Caledonia, plant, planted June, 1921.

Layout—

17 plots, each $\frac{1}{6}$ acre, consisting of 8 lines each, 5 feet wide and 181.5 feet long.

Plan—

9-A plots Lupines;
8-B plots no Lupines;
Fertilization—Uniform by plantation.
Experiment harvested by Mr. J. S. B. Pratt, Jr., with the help of the plantation.
Cane sampled in carload lots by Mr. Murray, the plantation chemist.

Iron, Aluminum and Manganese in the Soil Solution of Hawaiian Soils

By W. T. McGEORGE.

In a recent study of the methods of estimating and detecting acidity in Hawaiian soils (12) facts were noted strongly indicating the salts of iron, aluminum and manganese to be involved.

Until recently the presence of free acid in acid soils was the only factor considered to be involved in their low fertility. In 1913 Abbott, Conner and Smalley (1) published results showing a definite relation between low root vitality of corn and soil reaction. They found associated with this high acidity comparatively large amounts of soluble iron and aluminum salts. This work has been the incentive for numerous other investigations which have led to the suggestion that the toxicity of aluminum and manganese salts soluble in acid soils is of greater import than the hydrogen ion concentration itself. The toxicity of alkali soils has long been attributed to the high concentration of certain alkali salts. It is interesting to note the more recent trend of soil acidity interpretations on the basis of injuriously high concentrations of acid reacting salts.

In examining acid Hawaiian soils, the main characteristic, as in other acid types, is the absence of easily soluble bases calcium and magnesium and soluble phosphates. Such conditions are conducive toward the accumulation of acid reacting salts of iron, aluminum and manganese with free hydrogen ions formed by their hydrolysis in aqueous solutions. This in spite of the comparatively high base and low silica content of Hawaiian soils.

In view of the recognized toxicity of certain concentrations of these salts in the soil solution a further study of the nature of these existent compounds in our soils seemed imperative. Both sugar cane and pineapples, the principal commercial crops of the Islands, have shown positive evidences of low root vitality on some of the highly acid Island soils.

OCCURRENCE.

Aluminum: Aluminum occurs in Island soils chiefly as the phosphate, hydrate, oxide and silicate, the two latter compounds being also present in hydrated forms. It is the most abundant basic element. In both the lava and volcanic ash, aluminum is far in excess of iron and manganese and almost equal to the silica content if expressed as the oxide, Al_2O_3 . During the process of disintegration the per cent aluminum in the residual products is greatly increased and still in large excess over all other elements except silica. On the basis of 30 per cent Al_2O_3 and calculated on the basis of 3,000,000 pounds soil per acre foot there is present 900,000 pounds alumina per acre. It is present in largest amounts in the clay and fine silt particles, but even in the coarser particles is often in excess of 20 per cent.

There appears to be some diversity of opinion as to the occurrence of aluminum hydrates in mainland soils. In fact this applies generally to all temperate climates where environment induces kaolinization rather than laterization. Mirasol (13) has concluded, however, from a review of the literature that evidence indicates their presence in some mainland soils. The three recognized hydrates of aluminum are: Diaspore $\text{Al}_2\text{O}_3 \cdot \text{H}_2\text{O}$, Bauxite $\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$, and Gibbsite $\text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$. The two former are insoluble in dilute acids, alkalis and water, while Gibbsite is soluble in dilute acids and alkalis but insoluble in water. We therefore look upon the latter as the principal source of soluble aluminum. In applying these facts and theories to Island conditions it is significant that in our yellow soils, which are in a higher state of hydration, and in other types which are high in water of hydration, aluminum is present in larger quantities soluble in dilute acids. Tropical environment, which is known to induce a higher concentration of Gibbsite in the residual products of disintegration is also existent. Evidence therefore strongly indicates the presence of this hydrate in a large percentage of our Island soils.

We also have strong evidence of the presence of aluminum silicates and alumino-silicic acids which are more or less soluble in water and by dissociation the latter will yield hydrogen ions to a small degree. We have present therefore a large reserve of potential acidity.

Iron: Iron, like aluminum, occurs chiefly as silicate, oxide (principally ferric oxide) and hydroxide. The iron content of the lava and volcanic ash is much lower than aluminum and approximately equal to the lime and magnesia, usually being about 10 per cent. It is greatly increased in the residual products of disintegration but is still much lower than the aluminum content of the soil. The soluble salts of ferric iron are much less stable than those of aluminum, their hydrolysis and precipitation being, under soil conditions, proportionately more rapid. In our highly puddled and poorly aerated soils ferrous salts are usually present in varying amounts.

Manganesec: Manganese occurs chiefly as the silicate and oxide widely scattered in all soil types in amounts varying from a few tenths of a per cent to 10 per cent. It is present in the lava and volcanic ash in only small amounts, being rarely as high as 1 per cent and usually about .5 per cent. During the process of disintegration it appears to be readily dissolved, and that present in the residual products is greatly reduced by weathering agents. For this reason the Island soils are proportionately lower in manganese than the lava, except in certain isolated lower areas of the alluvium where soluble manganese salts have accumulated and precipitated as the dioxide, often as high as 10 per cent.

Veitch (16) in a study of the Hopkins method of determining soil acidity was probably the first to call attention to the role of aluminum salts in acid soils. He noted the presence of aluminum in the extract obtained by shaking an acid soil with a solution of potassium nitrate. This solution of aluminum was attributed to the replacement of aluminum by potassium in the alumino silicates. Parker (14) concludes that this solution is due to a side reaction and the solvent action of acid formed by the selective absorption of the basic ion of the salt solution. Additional theories of the source of soluble aluminum in the soil solu-

tion involve that of Ames and Boltz (2), who attribute its solution to the acidity resulting from sulphofication, and that of Abbott, Conner and Smalley (1), who suggest the formation of aluminum nitrate in the absence of adequate lime to neutralize the nitrate formed during nitrification. On the other hand we note that Denison (7) failed to identify soluble (crystaloidal) salts of aluminum in soil extracts, but did establish the presence of the hydrosol aluminum hydrate. Knight (12) also arrives at the same conclusion. Both question the formation of soluble salts of these elements in many acid soils.

The above contradictions suggested that we clarify some of these questionable points in Hawaiian soils and definitely determine the hydrogen ion concentration at which we can have a reasonable assurance of the presence or absence of the salts of these elements. In view of the apparent relation between some types of root-rot and soil acidity it is highly essential to be able to recognize more definitely the soil types in which this association is possible. So-called root-rot of sugar cane in Hawaii is not confined entirely to acid soils.

EXPERIMENTAL.

The logical procedure in the separation of colloid from crystalloid compounds involves the utilization of a semipermeable membrane. The plan of the experiment was therefore as follows: A definite selection of soils was made to cover a number of characteristic types. The soil solution itself as well as a salt solution extract were prepared and dialyzed for a definite period and the resultant changes in the soil solution determined.

CHOICE OF SOILS.

No. 1. A yellowish brown silty clay loam from Kaneohe district, island of Oahu. Pineapple plants badly wilted, sugar cane had previously failed.

No. 2. A brown silty clay loam from Kaneohe district, island of Oahu. Pineapple plants badly wilted, sugar cane had previously failed.

No. 3. A bluish grey adobe soil, Waimanalo district, island of Oahu. A low poorly drained soil on which a resistant cane variety grows well.

No. 4. A dark grey sandy loam, highly organic, from Honokaa, island of Hawaii. Sugar cane root vitality very low.

No. 5. A dark grey sandy loam, highly organic, from Honokaa, island of Hawaii. Growth of cane only fair.

No. 6. A chocolate brown silty loam, highly manganiferous (7 per cent MnO_2). No indication of poor root growth.

No. 7. A dark clay loam, from Experiment Station plots, Honolulu. Good root growth.

No. 8. A black clay soil from Waimanalo, Oahu, similar to No. 3, but sufficiently impregnated with lime to make alkaline.

EXPERIMENT 1.

Potassium Nitrate Extracts.

Four hundred grams of soil were shaken, with one litre of a normal solution of KNO_3 , continuously for three hours in an end-over-end shaking machine. Two hundred and fifty cc. aliquots of this filtrate were used for analysis. One was analyzed direct while the other was placed in a pyralodion sack. The sack and contents were suspended in an 800 cc. beaker, distilled water added to a level above that of the solution within the sack and the whole placed in a water bath. This bath was maintained at a temperature of 45°C . and the water in the beakers changed daily for a period of two weeks. At the end of this time the solution remaining in the dialyzing sack was subjected to the same analytical procedure as the original extract. The results are given in the following table:

TABLE 1.

Showing Analysis of KNO_3 Extracts Before and After Dialysis Results as Per Cent.

Soil No.	P H	Original Extract				Non-Diffusible Extract			
		SiO_2	Fe_2O_3	Al_2O_3	Mn_2O_3	CaO	SiO_2	Fe_2O_3	Al_2O_3
1	4.46	.0043	.0809	+	.0350	.0020	.0030	—	—
2	4.46	.0045	.0106	+	.0443	.0000	.0015	—	—
3	4.93	.0115	.0199	+	.4480	.0000	.0015	—	—
4	5.39	.0020	.0019	+	.1129	.0000	.0004	—	—
5	5.98	.0045	.0027	—	.1806	.0000	.0017	—	—
6	6.00	.0110	.0018	—	.2422	.0009	.0015	—	—
7	7.76	.0050	.0018	—	.3794	.0029	.0012	—	—
8	7.90	.0023	.0016	—	.6230	.0000	.0016	—	—

All extracts were evaporated to dryness on the steam bath and heated in the hot air oven at 120°C . to dehydrate the silica. The acid insoluble residue from this operation was weighed as silica. Iron and aluminum were determined together as phosphates and precipitated in the presence of acetic acid in order to avoid calcium contamination. Manganese was not determined quantitatively.

The results definitely prove the presence of crystalloid forms of iron aluminum and manganese in all the soils below pH 5.9 and indicate that above pH 6.0 only the hydrosol forms are present, while the manganese is entirely absent. This in spite of the fact that soil No. 6 contains 7 per cent MnO_2 . Dialysible forms of silica are present in all the soils, there being little or no colloid forms present in solution. Manganese and calcium are present entirely in dialysible forms.

In addition to the data given in Table 1 titrations of the KNO_3 extracts were also made on the original extract and the contents of the paralodion sacks after dialyzing for two weeks. In this titration 125 cc. was boiled for ten minutes and then titrated with .2 N KOH using phenolphthalein as an indicator. All the extracts within the paralodion sacks were practically neutral. The titration in cc. .2 N KOH are given in Table 2.

+ Present but not determined quantitatively; — not present.

TABLE 2.

Showing Titration of KNO_3 Extracts as cc. .2 N KOH per 125 cc.

Soil No.	Original Extract	Non-Diffusible Extract
1	6.00	neutral
2	1.10	neutral
3	2.60	0.05
4	0.80	neutral
5	0.60	neutral
6	0.10	0.10
7	alkaline	0.10
8	alkaline	neutral

These results definitely show the acid or acid salts present in the KNO_3 extracts to be present in a form which will penetrate a semipermeable membrane in entirety.

EXPERIMENT 2.

The soil solution was next obtained from this same set of soils and dialyzed according to the following procedure. Five pounds of soil were added to each of 5 glass percolators, distilled water added to saturation and the whole allowed to stand for 48 hours. They were then treated by the displacement method as outlined by Parker (14) which had previously been shown to yield the actual soil solution when applied to Hawaiian soils. In this case distilled water was used as a displacing liquid. The first 200 cc. of percolate was collected from each giving one litre total. Two hundred and fifty cc. of this soil solution was placed in paralodion sacks and dialyzed as described in Experiment 1. The remaining 750 cc. was analyzed direct. The results are given in Table 3, expressed in milligrams per litre of the solution. It should be mentioned that this solution is probably less concentrated than the actual soil solution owing to the addition of water up to the point of saturation, but the results are comparable and serve well for determining the diffusibility of the components of the soil solution.

TABLE 3.

Showing Analysis of Soil Solution Before and After Dialysis, as Mgs. per Litre.

Soil No.	Original Soil Solution					Non-Diffusible Solution			
	pH	SiO_2	Fe_2O_3 Al_2O_3	Mn_3O_4	CaO	SiO_2	Fe_2O_3 Al_2O_3	Mn_3O_4	CaO
1	4.46	3.6	7.2	0.8	30.9	0.8	1.6	—	—
2	4.46	10.5	15.1	18.3	116.9	0.8	4.4	—	—
3	4.93	66.5	10.0	4.0	117.2	0.8	1.2	—	—
4	5.39	19.1	8.2	3.3	550.4	0.4	3.2	—	—
5	6.00	16.5	0.8	0.0	29.6	not det.	not det.	—	—
7	7.76	27.7	4.0	0.0	91.1	2.0	3.6	—	—
8	7.90	41.2	3.7	0.0	274.4	0.4	3.6	—	—

— Not present.

These results compare very closely with those obtained by extracting the soil with KNO_3 solution. The iron and aluminum are present in largest part in the crystalloid form in all the soils of pH 5.5 or less while the manganese was not present in the soil solution above pH 5.9.

DISCUSSION.

In view of the results obtained in the preceding experiments it is interesting to compare with similar investigations. Knight (12) in a study of the Hopkins method, subjected the KNO_3 extract to dialysis in a collodion sack. In his experiments 74 per cent of the titratable acidity passed through the membrane but no aluminum. All the latter remained in the collodion sack, showing it present entirely in colloid form. The pH of his soil is not given, but it showed a higher titratable acidity than any used in these experiments. Similarly Denison (7) in leaching several Illinois soils with normal KNO_3 solution obtained no dialysible aluminum salts. Therefore he concludes a single treatment of the soil with KNO_3 solution yields only the hydrosol aluminum hydrate. On percolating water through this soil he was unable to obtain a test for aluminum from five litres of percolate. Unfortunately, he does not give the pH of the acid soils used.

On the other hand, Mirasol (13) found that by leaching acid soils with normal KNO_3 solution he was able to remove a large per cent of the iron, aluminum and manganese salts and effect a corresponding reduction in acidity. Similarly, with water he noted a marked reduction of acidity corresponding with the removal of soluble salts of the above elements. His work has been severely criticized in view of the fact that he based his conclusions on the analysis of the soil before and after treatment. He therefore failed to distinguish definitely between colloid and crystalloid forms and did not actually demonstrate the presence of soluble salts.

Abbott, Conner, and Smalley (1) determined the aluminum in the leachings from an acid soil in which corn roots were badly rotted, but did not distinguish between crystalloid and colloid, assuming the former. Hartwell and Pember (9) did not analyze the soil extracts, but determined the toxicity of diffusible and non-diffusible portions. Ruprecht (15) found iron and aluminum salts in acid soils of low fertility after filtering through unglazed porcelain. Blair and Prince (3) have also determined iron and aluminum in water extracts of acid soils without attempting to distinguish between crystalloid and colloid forms.

It is evident from the above that there is more or less difference of opinion as to the forms in which iron and aluminum salts are present in the soil solution, and some positive results supporting the non-existence of crystalloid forms.

From the data given in Tables 1 and 3 coupled with other observations it may be definitely stated that all Hawaiian soils of pH below a point between 5.5 and 6.0, believed by the writer to be 5.8, contain soluble salts of iron, aluminum and manganese. Whether toxic toward plant growth will depend upon associated environment, more especially the available phosphates present in the soil.

It is hardly believed from the results thus far obtained that soluble iron salts are a factor. While no attempt has been made in the analysis of the soil extracts to separate iron and aluminum it was possible to judge from the color

of the precipitate the relative amounts present. Aluminum was present in excess in every case. Iron salts hydrolyze more rapidly under soil conditions and precipitate as $\text{Fe}(\text{OH})_3$. It may be of interest to state that in attempting to prepare nutrient cultures for studying the toxicity of iron salts, it was found impossible to keep iron in solution even at a concentration of N/5000. These facts strongly indicate the minor role which iron must play in any toxicity of our acid soils. This refers only to ferric salts. Frequent instances have been noted in Island soils where puddled and poorly aerated areas have been found to contain appreciable amounts of ferrous iron. Such soils are usually characterized by a bluish grey color. ✓

Of the soluble salts found associated with acid soils aluminum has been found to be the most toxic and for this reason the reduced growth of many plants on such soils has been attributed to the presence of salts of this element in the soil solution. In our highly organic soils the aluminum appears to be present in large measure as organic salts of high potential yet low intensive acidity. The solubility in dilute acids is very high, with comparatively low solubility in water. Burgess (4) has published a method for the determination of aluminum in which he classifies that soluble in .5 N acetic acid as "active". Applying this method to Hawaiian soils some have been noted as over 2,000 p.p. mil. while an even higher content of active iron has been noted in highly puddled soils. Analytical evidence therefore strongly indicates the presence of toxic amounts of aluminum in many of our acid soils.

The solubility of manganese is of special interest in its relation to the chlorotic condition of pineapple plants and the absence of chlorosis of sugar cane grown on the manganiferous types. The principal physiological disturbance is, according to Kelley (11), due to an abnormal absorption of calcium by the plants grown on the manganiferous soils, while Johnson (10) claims a toxic effect from manganese. No manganese soils have been noted by the writer with a pH below 5.9 and no manganese has been found present in the soil solution at this pH or higher. Soil number 6 is a typical manganiferous type. The theory advanced by Kelley (11) suggesting the higher assimilation of calcium appears the more tenable, sugar cane having a greater tolerance for calcium. The lower acidity which is typical of the manganiferous type and below the hydrogen ion concentration at which manganese salts have been found present in the soil solution and the greater absorption of calcium by plants on this soil type, makes the toxicity of manganese appear less tenable at this reaction. This does not deny the toxicity of manganese salts but merely points out their absence in the soil solution of this soil type. If manganese does exert a direct toxic effect as noted by Johnson (10) with pineapples grown in water cultures, we must associate this with soils of higher acidity in which their presence is definitely shown by the data in Tables 1 and 3. The influence of this factor on the growth of sugar cane is now being studied. Thus far there has been no evidence of any injurious nutritional disturbance with sugar cane grown on manganiferous soils. There is also no evidence of so-called root-rot of pineapples on the manganese soils, but only a chlorotic condition of the leaves attributed as above to the abnormal assimilation of calcium. There is, however, positive evidence of low root vitality

of both sugar cane and pineapples on some acid soils. All the soils of pH 5.5 or lower contain appreciable amounts of manganese in solution and it is not unreasonable to suspect a certain degree of toxicity on such types.

Carr (5), in studying the relation of manganese to soil acidity or toxicity, which terms he suggests as synonymous, claims the presence of soluble manganese up to a pH of 7.9. He bases his conclusions upon the work of Greenfield and Buswell (8) and the results obtained by himself, using the Comber method of testing for soil acidity. The former studied the precipitation of manganese as hydroxide using a fixed alkali, sodium hydroxide, and found precipitation complete only at pH 7.9. That this does not hold true under soil conditions is shown by the results given in Tables 1 and 3. Manganese soils in Hawaii are usually found in localized areas formed by the deposition of manganese as dioxide. Evidence indicates it to be present in the lavas in a form easily dissolved by the agents of disintegration. It is therefore precipitated at a pH far below 7.9 if we are justified in accepting the present pH of these soils as a criterion. This high concentration of manganese dioxide in localized areas and the absence of manganese in the soil solution of the soils above pH 6.0 may be attributed to the precipitation by lime at this pH range or the formation of manganic salts which being of extremely low stability will not remain in solution.

Comber (6) found that on shaking an acid soil with an alcoholic solution of KSCN he obtained a red color, ferric sulphocyanate, and suggested the use of this reagent in testing the soil reaction. Carr (5) in a study of this method noted the formation of a green color which he attributed to the presence of soluble manganese.

The writer has also obtained this green color with all soils of pH 5.5 to 7.0 and most soils above 7.0. Among the soils which Carr examined was a highly manganiferous sample from Hawaii in which he claims the presence of soluble manganese basing his conclusions on the green color obtained by the Comber test. While he does not state the pH of this soil it seems reasonable to assume that it is of approximately 5.9 or higher in view of the fact that the writer has failed to find a sample of this type below this figure. Being at a loss to explain Carr's conclusions after having failed to find soluble manganese in soils of this type and reaction some attention has been given to a study of this point.

Most Hawaiian soils contain at least .5 per cent manganese dioxide and will range from this up to 10 per cent. A soil of pH 5.5 or higher regardless of the amount of manganese dioxide present usually gives a greenish blue color, not immediately but only on standing, by the Comber method using ethyl alcohol as the solvent. Soils of pH 5.5 or less will retain their original red color. The writer believes, although it has not been absolutely proven, that there is strong evidence that this green color is due to the formation of manganese perchloride (MnCl_4). This suggestion is based upon a brief study of this color development, the fact that manganese is present in our soils principally as MnO_2 , the anhydride of tetravalent manganese hydroxide ($\text{Mn}(\text{OH})_4$) and further that manganese tetrachloride is one of the very few green manganese salts soluble in alcohol.

In determining why the green color, which appeared to be associated with the presence of manganese, is obtained with soils containing no soluble manganese

it was necessary to recognize the results given in Tables 1 and 3 showing no soluble manganese or other acid salts in the soils of pH 6.0 or higher in the KNO_3 extracts. That is, there was no displacement with potassium nitrate under the conditions of this method.

In treating a manganiferous soil containing 10 per cent MnO_2 by the Comber method a faint pink color was obtained, as usually noted, fading to colorless and finally to greenish blue on shaking several times and allowing to stand. The original pH of this soil was 6.3, which on shaking with alcoholic KSCN dropped to pH 5.5, which is within the range at which manganese salts are in solution. In order to obtain further data on the increase in hydrogen ion concentration when shaken with this reagent, a series of soils was selected varying in pH from 4.4 to 8.0. These soils were shaken with alcoholic KSCN in the proportion of one part soil to two parts 5 per cent KSCN in alcohol and the pH of the mixtures determined immediately and at intervals up to 24 hours. In all soils of pH 5.9 or higher the pH dropped to 5.5 and gradually changed to a greenish blue color. In the more acid soils the pH dropped considerably below 5.4 and all these retained their red color. In other words, the soluble manganese which Carr found is not actually present in the soil solution as such but is made soluble by the higher hydrogen ion concentration. On adding an excess of MnO_2 to the alcoholic extracts of all the soils which retain their red color the hydrogen ion concentration will lower rapidly to a pH of 5.5 or slightly higher, discharging the red color. The color therefore appears to be a function of the hydrogen ion concentration. This is further indicated by the fact that a filtered Comber extract which is green will change to a red color on slightly increasing the hydrogen ion concentration.

CONCLUSIONS.

The preceding data and discussion covering a study of typical soils from areas on which root-rot of pineapples and sugar cane is or is not existent strongly indicates the toxic compounds associated with acid soils to be related to the reduced plant growth on such areas. The role which the salts of aluminum and manganese play is not clearly understood, although the association of phosphate starvation is apparent. This point is being studied in water, sand and soil cultures involving first the toxicity of aluminum and later based on the data submitted in this paper, the toxicity of manganese salts and aluminates. Preliminary experiments have already shown a marked toxic effect of aluminum salts toward sugar cane. It is therefore not unreasonable to assume a definite relation between the presence of aluminum salts and possibly manganese in our highly acid soils and low root vitality which we find present on the cane and pineapple plants grown on such areas.

But we cannot explain by the above theories the root-rot which eliminated the Lahaina cane from the coral lands of Oahu, Ewa and Honolulu plantations. The reaction of these soils is approximately pH 8.0 and they are usually high in available phosphate, the very environment in which aluminum salts are not present. The only possibility of aluminum being a factor, in such soils, is the presence of aluminates which appears to be only vaguely tenable. Blum has

shown that in precipitating aluminum salts with a fixed alkali precipitation is complete between pH 6.5 and 7.5. From 7.5 to 8.0 or higher aluminum will redissolve as the aluminate (i. e., $\text{Na}_2\text{Al}(\text{O}_2)$), the sodium and potassium salts being very soluble in water. The calcium salts are, however, very insoluble. The theoretical possibility of soluble aluminates is therefore evident in alkaline soils. The amphoteric nature of aluminum hydrate introduces complications which cannot be ignored and would theoretically permit the presence of aluminates. We must further recognize the ability of plants to feed on apparently insoluble minerals, although there is no evidence to indicate the assimilation of toxic amounts from such sources. The latter applies to manganese and iron as well as aluminum.

SUMMARY.

1. Normal potassium nitrate does not displace the aluminum in aluminum silicates except in those soils of pH below 6.0.
2. Soluble crystalloid salts of iron, aluminum and manganese were found only in those soils of hydrogen ion concentration below 5.8.
3. At pH 6.0 or above manganese is not present in the soil solution and iron and aluminum only as the hydrosols of ferric and aluminum hydrates.
4. The solubility of manganese as indicated by the Comber test is due to the lower pH developed on shaking a soil with alcoholic potassium sulphocyanate.

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Chlorid of Lime as a Soil Disinfectant*

By DR. OSCAR LOEW.

Among the media serving as soil disinfectants thus far only bisulfid of carbon and carbolineum are sufficiently low in price for practical purposes. I found, however, some years ago that chlorid of lime is just as effective and considerably cheaper.

Chlorid of lime is generally considered as a mixture of calcium chlorido-
 Cl
 hypochlorite $\text{Ca} = \text{O.Cl}$ with calcium hydroxid. By its decomposition in contact
 Cl

with carbon dioxid chlorin is set free, $\text{Ca} = \text{O.Cl} + \text{CO}_2 = \text{CaCO}_3 + \text{Cl}_2$. This free chlorin will spread in the soil to which chlorid of lime has been applied and kill all sorts of animal and vegetable organisms. Only certain bacteria and spores will resist, and then when the chlorin is not too concentrated. A loam soil poor in humus was given 300 grams of chlorid of lime per square meter mixed uniformly to the depth of about 10 centimeters. After five days it was found that the denitrifying bacteria had decreased to mere traces; the "desulphurization" bacteria had been entirely annihilated and the butyric bacilli had decreased to about one-third of the original number, probably due to their resistant spores.

The killed organisms will yield up their mineral nutrients and nitrogenous compounds furnishing ammonia for the roots of the plants grown there later on, after the chlorin is either volatilized or transformed into hydrochloric acid. This latter acts again on calcium carbonate of the soil with the production of calcium chlorid.

The more organic matter like humus contained in a soil, the more rapidly the free chlorin will pass by causing oxidations into hydrochloric acid and this into chlorids. On the other hand a high content of clay may delay the destruction of the chlorid of lime by enclosing particles of it and preventing the access of carbon dioxid contained in the pores of the soil. Thus it can easily be understood that the time for the destruction of the chlorid of lime may vary from eight days to two months, as was shown by tests with potassium iodide and starch upon the aqueous acidulated extract of the soils.

An application of 100-200 grams of chlorid of lime to the square meter will suffice on ordinary soils, while at least 300 grams will be required on soils infected with parasitic nematodes, fungi and injurious microbes. In some cases it will be found preferable to treat the chlorid of lime with about 10 times its weight of water and to apply only the supernatant liquid to the soil, while the sediment of calcium hydroxid or slaked lime may be used elsewhere. Care should be taken in handling the chlorid of lime, as it will attack skin, eyes and lungs.

The following described experiments were made on tired soils which were continuously planted to the same crop and also on healthy soils:

* From a circular of the Porto Rico Experiment Station.

1. On the lily beds of a Botanic Garden the development of *Lilium Candidum* went from bad to worse. The leaves turned yellowish and the number of flowers decreased from year to year, although some change of the soil in the bed was made by renewing it. The roots died off gradually and underwent putrefaction. Noxious insects and nematodes were not discovered on the roots. Of this bed five lots 1.5 square meters each were used for the experiments. No. 1 served as control, 2 received 100 grams of chlorid of lime; 3 potassium permanganate, 110 grams, dissolved in 5 litres of water; 4 tricresol, 30 grams, suspended in 5 litres of water; 5 bisulfid of carbon, applied in five holes of 20 cm. depth which were closed and the soil was well watered.

Six weeks after these applications an equal number of tubers of *Lilium Candidum* 20 cm. high were transplanted from the culture pots upon these five lots. After two months development the following results were observed:

Treatment	Number of		Height of Stems (Average) cm.
	Stems	Flower Buds	
Control	4	18	69
Chlorid of lime	8	55	90
Permanganate	6	31	65
Tricresol	7	39	62
Bisulfid of carbon	5	35	67

As noted the chlorid of lime produced the best results.

2. In a vegetable garden a steady decrease of the harvest of cabbage and radish was observed. We treated one of the beds with 300 grams of chlorid of lime per square meter. Three weeks later cabbage was planted. At harvest time every plant was found healthy, while on the control bed the usual injury was evident.

3. In a commercial flower garden several beds had become very unproductive in spite of rich manuring. Young violets and carnations, also young poplar trees, gradually withered and died. My investigation revealed the presence of nematodes. On lots of 4 square meters each the following treatments were applied:

1. Chlorid of lime, 500 grams, mixed with the soil which was then well watered. 2. Carbolineum, 500 grams, mixed with 4 litres dry peat soil then well worked into the ground. 3. Bisulfid of carbon, 500 grams, applied to five holes which were then filled up with earth and well watered. 4. Served as control.

Three weeks later 160 aster plants were transplanted from the seed bed. On three plots on the carbolineum plot the planting took place six weeks later. Two months afterwards the number of dead plants were counted with the following results:

On the bed of chlorid of lime	3.8%
On the bed of carbolineum	3.1%
On the bed of bisulphid of carbon	22.5%
On the control bed	34.4%

It will be noticed that chlorid of lime surpassed the carbon bisulfid considerably in effectiveness.

4. On a loam soil very well manured with compost and apparently normal and healthy, chlorid of lime was applied at the ratio of 200 grams per square meter. Each lot measured 6 square meters. A second lot received the equivalent amount of calcium carbonate, while a third lot served as control. Cabbage and beets were planted two months later upon these lots, and equal number on each. On another field (loam soil) potatoes were planted on lots of 9 square meters each. The yields are shown in the following table:

	Chlorid of Lime	Carbonate of Lime	Control
Cabbage	13.6 Kg.	8.9 Kg.	10.4 Kg.
Beets	54.8 "	31.1 "	33.0 "
Potato (2 lots each)	21.3 "	41.9 "	12.1 "

It will be noted that in all these cases the chlorid of lime treatment was very satisfactory. It was especially striking that the lots treated with chlorid of lime had remained free from undesirable weeds, in contrast to the other lots, and that the potato leaves excelled in their deep green coloration.

These experiments indicate that agriculture may derive considerable advantage from the judicious and proper application of chlorid of lime.

Reviews

Field Control of Tomato Mosaic, by Max W. Gardner and James B. Kendrick,
In Phytopathology, Vol. 13, No. 8, August, 1923, p. 372.

Tomato plants are subject to a mosaic disease of a similar character to the mosaic disease of sugar cane. The authors of this article have pointed out the importance of perennial weeds as winter carriers of mosaic disease of the tomato and recommended the eradication of such weeds as the ground cherries, *Physalis subglabrata*, *P. virginiana* and *P. heterophylla* and the horse nettle, *Solanum carolinense* with the idea of removing the sources for infection from fields for tomato planting. To test out this recommendation the following experiment was undertaken:

Young tomato plants were obtained from virgin plant beds carefully protected to insure all plants in the experiment being free from the disease at the outset. Three separate fields were planted with these mosaic-free plants; field 1 of 10 acres, field 2 of 5 acres, and field 3 of 30 acres. In fields 1 and 2, a vigorous effort was made to keep down the weeds while field 3 was used as a control and weeds were allowed to appear, although the ordinary cultivation methods in field practice were followed. Fields 2 and 3 were planted during the third week in May and field 1, 2 weeks later.

On May 29 *Physalis* was appearing in and around all fields and fields 1 and 2 were weeded. A week later another weeding was necessary and thereafter

at approximately one week intervals until late in July in Field 2 and early August in Field 1. In Field 3 *Physalis* appeared but no special effort was made to combat it other than the usual horse cultivation.

On August 29 a count of affected plants was made in all fields with the following results:

	Number of Plants Examined	Percentage Mosaic Plants
Field 1 weeded	6,400	0.43
Field 2 weeded	3,600	1.80
Field 3 control	1,720	14.20

The authors conclude that entire freedom of the plant beds, and early efforts at weed control in the field greatly aid in minimizing mosaic disease in tomatoes.

The suggestions arising from a review of the foregoing experiment would be to have a number of replications of both weeded and control fields since the difference in percentage of mosaic plants recorded in the above experiment might easily have occurred through chance. Moreover it is apparent that in the control field, number 3, a complete count of plants was omitted, so that unless the methods for the count were described, some doubt might exist as to figures being representative.

There is very evidently a suggestion of possible value in mosaic disease control in sugar cane, resulting from this paper, however. It would seem desirable to follow up this suggestion by careful weed control experiments following planting until the cane has shaded in.

H. A. L.

Zinc in Boilers*

An inquiry regarding the use of zinc in boilers addressed to the Boiler Code Committee of the American Society of Mechanical Engineers brought out the following statement from the subcommittee on the Care of Steam Boilers and Other Pressure Vessels in Service, of which F. M. Gibson is chairman:

Zinc is used in boilers for two reasons—the prevention of scale and the prevention of corrosion.

As a preventive of scale there is conflicting evidence of its value. In some cases it is positively harmful and should be used with caution. Where it can be used safely, the same results can be obtained more positively by the means of feed-water treatment. It is of most benefit in selenitic waters, also where the scale consists of organic matter and lime and where sulphates and chlorides are in excess over carbonates. If only organic matter is present in the water, and zinc is used, a hard scale is formed which frequently causes over-heating. Carbonate of lime, carbonate of magnesium or carbonate of iron quickly renders

* Power, Vol. 58, No. 6.

the zinc brittle and porous and reduces it to powder. Zinc should not be used where feed-water compounds are used.

As a preventive of corrosion the use of zinc has been successful where there existed electrolytic action, air in feed-water or hydrochloric acid evolved from chloride of magnesium in sea water. Where used to counteract the action of air in feed-water, it should be placed near the entrance of the feed.

Zinc should be used only upon the advice of a chemist who is familiar with feed-water treatment.

The amount of zinc to be installed depends upon the conditions involved and ranges from 0.5 to 1.0 square foot of exposed surface, not including edges, to each 100 square feet of heating surface.

Zinc slabs should be made of one-half inch thick rolled plates and should be in good electrical connection with the metal of the boiler by means of copper wire or other good conductor of low electrical resistance. Where straps are used to hold the zinc in place, they should be filed bright where in contact with zinc and boiler material; after being bolted in place, the outside joints should be protected with red-lead putty. The joint between bolts and zinc should be made tight by means of red-lead putty.

Baskets, troughs or pans should be used to catch any disintegrated zinc. When a boiler, in which zinc is used, is opened for inspection, the zinc should be inspected, and if any oxidized zinc is found, the zinc should be scraped or renewed. When its thickness has been reduced to one-fourth inch, the zinc should be discarded and new zinc installed.

Attached is a digest of several references:

REFERENCES.

1. Kent, 1900, page 720: Zincs are often used; their action is electrical, hydrogen going to the iron shell, and the oxygen to the zinc. It is supposed to prevent corrosion. In numerous cases the action has been harmful. Where scale consists of organic matter and lime, the action has been beneficial. With organic matter alone there is a tendency to make hard scale of zinc oxide and organic matter, enough so as to cause overheating.

2. Tulley, page 107: Zincs are used in boilers to prevent corrosion and to prevent scale. It is used to prevent corrosion mainly in marine boilers. It is used to prevent scale mainly in boilers fed with fresh water. A perfect metallic contact must be insured. Used for the prevention of scale, the theory is that particles of zinc wasted away mixed with solid matter in water and prevented adhering in the form of hard scale. Now generally believed that it acts electrically to prevent corrosion as well as scale. When water contains an excess of sulphates or chlorides over the carbonates, the acids of the former form soluble salts with the oxide of zinc. If the water contains mostly carbonates, there is no great amount of reaction. In externally fired boilers zinc should be used with caution, as it is liable to produce a heavy sludge leading to overheating. The evidence is very conflicting.

3. Helios, Heine Boiler Co., page 49: . . . in ocean service some sea water is apt to be fed, which sets up electrolytic action. Zinc plates are, there-

fore, placed in the drum to act as the electro-negative agent and prevent corrosion. In the Heine Marine Boiler, the U. S. Navy standard is used; that is, three-fourth sq. ft. exposed zinc for each 100 sq. ft. heating surface. A perfect electrical contact is insured and a pressed-steel basket is provided to catch the disintegrated zinc.

4. Christie, page 137: Dr. Kossman says that the use of zinc in boilers for the prevention of scale is useful in selenitic waters, but as against the carbonate of lime, carbonate of magnesium and carbonate of iron, it is of little value, the zinc quickly rendered porous, brittle and reduced to powder.

Dr. Moore says the most important results from the use of zinc is the protection of the plates from hydrochloric acid evolved from the chloride of magnesium in the sea water.

Dr. Corbigny says the galvanic action liberates hydrogen which lies close to the boiler metal, and prevents scale from adhering.

Dr. Worlington says zinc removes oxygen from the water; 13 pounds of zinc results in zinc oxide and will remove 3.2 pounds of oxygen from one ton of water.

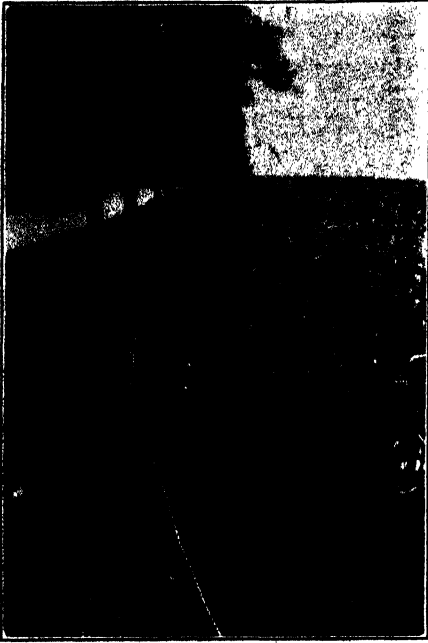
5. "Marine Steam" says the use of zinc appears still a very important element of protection against corrosion due to air in feed water. It is recommended as a positive benefit suspended near entrance of feed, as it deflects to itself from the iron harmful action. Charles H. Haswell suggested the use of zinc in marine boilers thirty years before the English engineers recommended the same thing.

6. "Gill's Engine Room Chemistry", page 92: Pitting may be prevented by the introduction into the boiler of plates of zinc, which are dissolved in plate, being frequently done in marine boilers. They must be bolted onto projections from the boiler itself, making a good electrical contact. For new boilers allow one square foot of zinc to each fifty square feet of heating surface and later one-half this amount.

(W. E. S.)

Plantation Notes—Illustrated

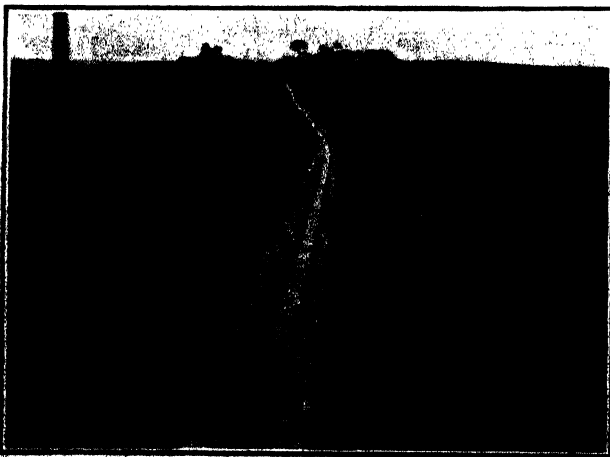
(Photographs by J. S. B. Pratt, Jr.)



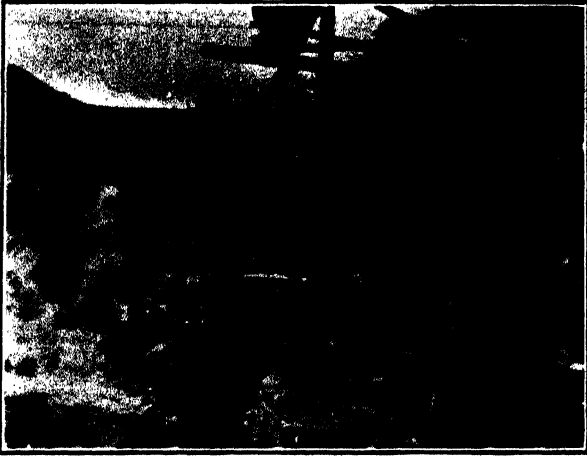
A dry ditch at Oahu Sugar Company prevents tree roots from encroaching upon the cane.



These ditch gates at Oahu Sugar Company can be held at any desired height through the simple device of a hinge which engages bolt heads placed two inches apart.



An effective drain at a roadside, Pepekeo, is made of half concrete pipe sections.



Difficulties in building flume trestle foundations to withstand freshets, have been met at the Hakalau Plantation Company by the use of a six-inch pipe standard set in concrete and reinforced with rail and cement. The arrow shows the high watermark of a recent torrent.

The flange at the top of the standard offers a means of bolting the woodwork to the foundation.

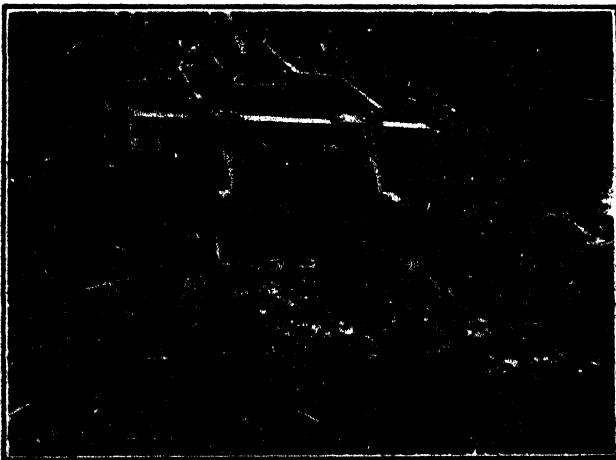


In looking down from the trestle the standard at the right is seen to have been slightly bent by the freshet, but the superstructure suffered no damage.

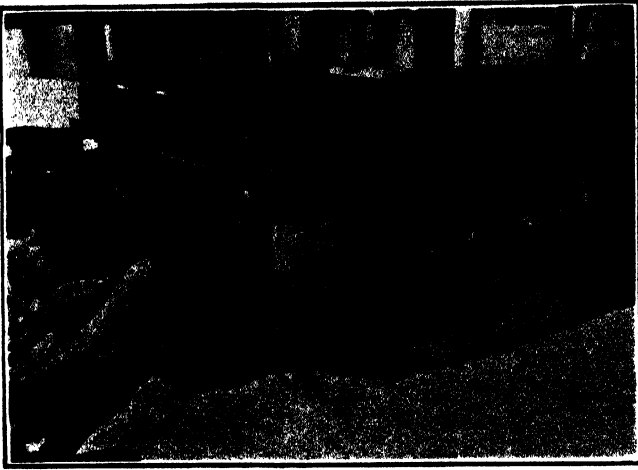


A tall observation pole denotes dry spots in Ewa's level fields, aiding in supervision of irrigation and in addition they are used in locating positions for firebreaks.

An instrument used at the Experiment Station for recording the hour-to-hour growth of cane leaves.



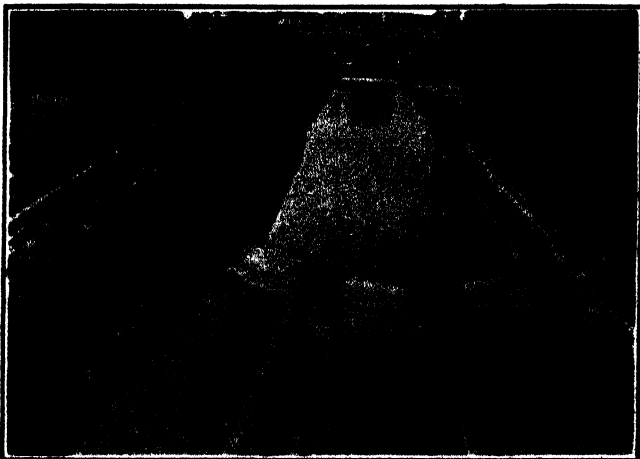
This type of off-barring plow is used on several Hawaii plantations.



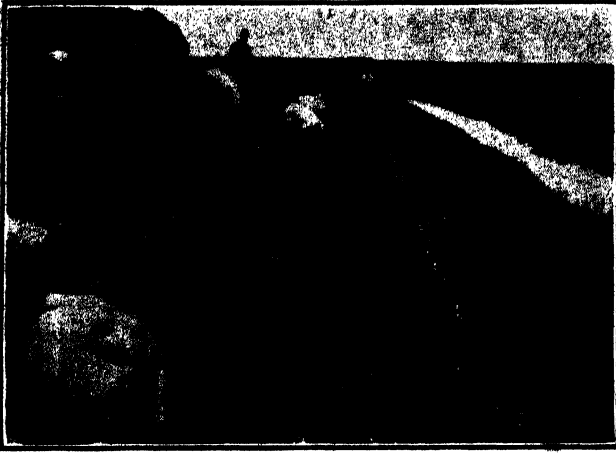
A convenient arrangement for drying sand for locomotives of the Oahu Sugar Company.



Mr. John Ross has used bright colored cannas effectively about the plantation buildings at Hakalau.

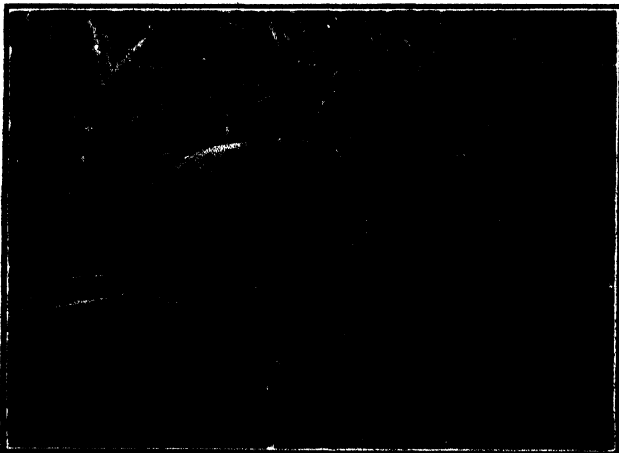
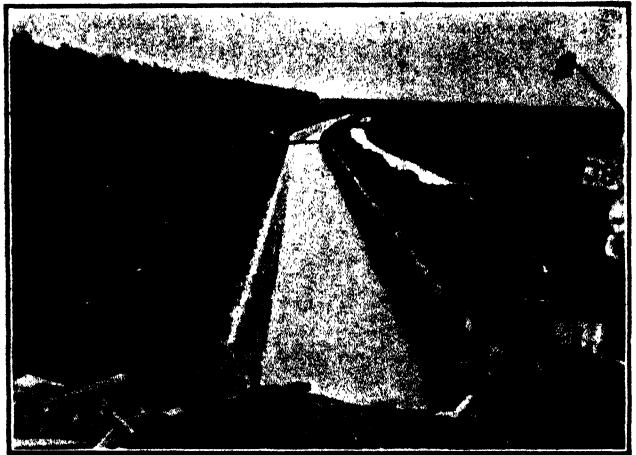


A seed soaking tank at Kahuku, which accommodates eight cars at a time.



A stone slab ditch under construction at Waipahu; the slabs are 1'x1'x4", and the bottom of the ditch is to be of 3" concrete.

The finished ditch.



A homemade road roller, Onomea, constructed from an old pulley by filling it with concrete after removing the flanges. The pulley was formerly used at the landing in shipping sugar.

Sugar Prices.

96° Centrifugals for the Period
December 16, 1923, to March 15, 1924.

Date	Per Pound	Per Ton	Remarks
Dec. 18, 1923.....	7.28¢	\$145.60	Cubas.
“ 22	7.22	144.40	Cubas.
“ 26	7.25	145.00	Cubas, 7.22, 7.28.
“ 27	7.22	144.40	Cubas.
“ 28	7.095	141.90	Cubas, 7.16, 7.03.
“ 29	7.03	140.60	
Jan. 4, 1924.....	6.53	130.60	Cubas.
“ 7	6.465	129.30	Cubas, 6.53, 6.40.
“ 8	6.28	125.60	Cubas.
“ 9	6.40	128.00	Cubas.
“ 10	6.465	129.30	Cubas, 6.40, 6.53.
“ 11	6.53	130.60	Cubas.
“ 14	6.65	133.00	Cubas.
“ 15	6.715	134.30	Cubas, 6.65, 6.78.
“ 16	6.59	131.80	Cubas, 6.65, 6.53.
“ 19	6.53	130.60	Cubas.
“ 23	6.65	133.00	Cubas.
“ 25	6.78	135.60	Cubas.
“ 28	6.75	135.00	Cubas, 6.72, 6.78.
“ 29	6.8433	136.87	Cubas, 6.78, 6.91; Porto Ricos, 6.84.
“ 30	6.91	138.20	Porto Ricos.
Feb. 2	7.095	141.90	Cubas, 7.03; Porto Ricos, 7.16.
“ 4	7.28	145.60	Cubas.
“ 7	7.22	144.40	Cubas, 7.28, 7.22, 7.16.
“ 13	7.41	148.20	Cubas, 7.41.
“ 14	7.28	145.60	Cubas.
“ 15	7.21	144.20	Cubas, 7.16, 7.28; Porto Ricos, 7.19.
“ 16	7.22	144.40	Cubas.
“ 18	7.16	143.20	Cubas.
“ 20	7.09	141.80	Cubas.
“ 25	7.41	148.20	Porto Ricos.
“ 26	7.22	144.40	Cubas, 7.28, 7.16.
“ 27	7.16	143.20	Porto Ricos.
Mar. 3	7.09	141.80	
“ 4	7.16	143.20	Cubas.
“ 7	7.09	141.80	Cubas.
“ 10	7.16	143.20	Cubas.
“ 11	7.09	141.80	Porto Ricos.
“ 12	7.03	140.60	Cubas.

THE HAWAIIAN PLANTERS' RECORD

Volume XXVIII.

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Number 3

A quarterly paper devoted to the sugar interests of Hawaii and issued by the Experiment Station for circulation among the Plantations of the Hawaiian Sugar Planters' Association.

Forty years ago A. Jaeger addressed a communication to the **Seed Cane** Hawaiian Planters' Monthly on the subject of seed cane. His letter, which was published in the issue of that journal of April, 1884, is here reproduced because of the pertinent bearing it has on the general question of better seed cane as discussed today. Mr. Jaeger wrote:

"The time, I believe, has arrived for cane planters on these Islands to pay more attention than heretofore to the selection of their seed cane.

"On most plantations it is the custom to grind all of the best cane in order to produce for the present season the largest possible quantity of sugar, and leave the poorest portion of a ratoon field for seed to plant. This is a mistake, because under such auspices sugar cane or any other plant under cultivation, will and must deteriorate according to the laws of nature, be such deterioration fast or slow, according to circumstances, it is nevertheless sure, and one ought not to be surprised at the common cry of late 'Our cane is running out.'

"The exchanging of seed cane between plantations may have proved beneficial in some instances, whilst no doubt it has done harm in others. This is, however, but trying to put off the evil day, for if much depends upon cultivation, everything depends upon the quality of seed in order to obtain the results wished for.

"The introduction of some twenty new varieties of cane from Mauritius, which have been largely distributed among our planters, will not remedy the evil. Their fate will be the same as that of our well-known kinds, unless proper care is taken of them, and in that case some varieties may prove to be a boon to our planters.

"Every plantation ought to set aside a portion of its best land and cultivate with the greatest care the cane needed for seed, which should not only be of the variety best suited to the locality, but also of the best stock obtainable. It should be looked after better than any other cane on the plantation, in order to improve the quality, rather than allow it to deteriorate.

"A planter, with whom I conversed about the matter at hand, believes that the early success which attended the cultivation of the Lahaina cane was principally due to its being carefully raised in nurseries, which was necessary at the time in order to produce sufficient seed of this variety for planting.

"It may be cheaper and in instances perhaps preferable for a plantation to spend a sum of money annually in purchasing such seed cane as it needs, if of

the kind and quality desired. In that case there would be a splendid opening for some one possessed of the suitable lands and energy to cultivate the very best quality of seed cane in order to supply those plantations in need thereof. Should this great need not as yet be apparent to many, it soon will be.

"I have always found that cuttings, roots, and even seeds taken from vigorous, healthy parent plants, will produce vigorous and healthy offsprings, which generally remain so during life, whilst those from neglected undersized stock seldom improve even under favorable circumstances, but are more liable to disease or to be attacked by insects.

"In Europe and perhaps also in America, farmers, gardeners and others have found it to their interest to procure the principal portion of seed they need annually from reliable nurserymen; those seeds having continuously proved to bring about better results than those raised by themselves.

"The cultivation of sugar cane is not much different from that of potatoes and until the last quarter of a century very little attention was paid to their cultivation as far as selection of seed was concerned; in fact, those potatoes which were not worth peeling, were picked out for seed year after year. The result of it was, that the crops of this important article of food failed. A disease, unknown during the first centuries after its introduction into Europe, made its appearance and many farmers seriously contemplated abandoning the cultivation of the potato altogether. This was about thirty years ago; but since then much has been done to improve the potato. It again yields good crops and the disease which affected them and made them unfit for human food has disappeared; but the only way this change could have been brought about was through high cultivation and careful selection of the seed. At the present day this is principally done by nurserymen, who make it a business to raise and collect seed for forestculture, agricultural and horticultural purposes, to supply the market.

"I have before me a catalogue of 1884, issued by a German seed house, which enumerates not less than 13,391 different kinds of seeds including 209 varieties of potatoes. As the prices of many seeds are quoted by the cwt., it may give an idea to what an extent these establishments are patronized."

Honolulu, March 21, 1884.

The Mexican Armyworm Parasite (*Euplectrus Platyhypenae*)

By O. H. SWEZEY.

We first received this little parasite from Mexico, April 4, 1923. In cane fields at El Potrero, Vera Cruz, Mr. H. T. Osborn found caterpillars of an armyworm (*Cirphis latiuscula*) very similar to the armyworm (*Cirphis unipuncta*) we have in Hawaii. Many of the armyworms were found to be parasitized, and four consignments of them were sent to the Station at intervals of about a

week. One consignment never reached us. Another was delayed for a week in San Francisco so that it arrived with the one sent a week later. The best consignment was received on April 4.

In this consignment Mr. Osborn had put 20 caterpillars collected in the field, on which were the full grown larvae of the parasites, and 25 caterpillars having parasite egg clusters on the surface. On arrival about 200 of the parasites had already matured and were still living. More of the parasites matured in the next 3 days so that we had altogether 454 of the parasites. Three hundred and fifty-two of these were sent to the Parker Ranch at Waimea, Hawaii. The remainder were retained for experiments in rearing them at the Experiment Station.

Several kinds of caterpillars were tried with the parasites, and they were found to oviposit on any kind of armyworm or cutworm caterpillar that was available. The nut grass armyworm (*Spodoptera mauritia*) was the most convenient to make use of, as successive broods of the caterpillars could be reared in the insectary to keep up a supply on which to rear the parasites.

The first brood of parasites matured in about 2 weeks, and continual rearing was carried on for over a year. Colonies of from 100 to 1,000 of the adult parasites were sent out to the sugar plantations on the various islands and such other places as it was learned that armyworms were present. By far the larger number of them went to Hawaii where armyworms are more prevalent in certain fields of the plantations that are adjacent to grassy regions where the armyworms are apt to be present a good part of the year. Altogether 45,915 of the parasites were distributed up to May 8, 1924. The Division of Entomology of the Board of Agriculture and Forestry was also supplied with this parasite and rearing for distribution has also been carried on in their insectary.

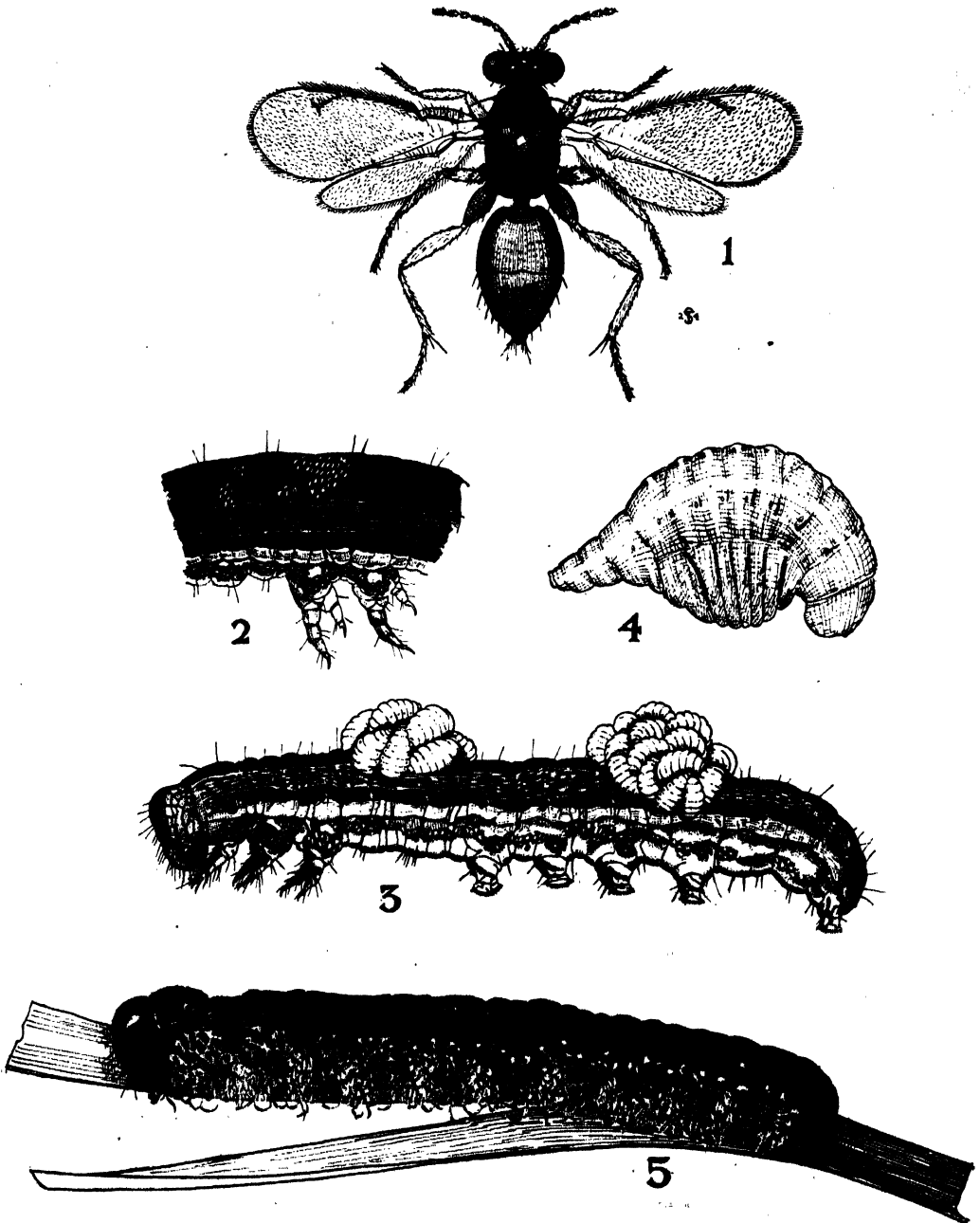
If this parasite succeeds in becoming established under our climate and conditions, it should help considerably in controlling the armyworms.

LIFE HISTORY.

The eggs are white when first laid, but turn black in a few hours. They are placed in clusters of from 5 to 30 on the surface of the caterpillar; are somewhat regularly arranged in rows, near to one another, but not touching. There may be several of these clusters on one caterpillar, and placed most anywhere on the upper surface or sides. As many as 50 and 75 eggs have been counted on one caterpillar. During oviposition the female parasite sits quietly on the caterpillar, which usually seems quite unconcerned about it, though at times a caterpillar is observed to try to rid itself of the parasite. Apparently the caterpillar is not paralyzed, though the parasite seems to insert its ovipositor slightly into the caterpillar before the laying of each egg.

The eggs hatch in 3 days, and the young larvae begin feeding on the caterpillar at the place where located, by inserting their mouths through the caterpillar's skin and sucking its body fluids. The caterpillar goes on feeding for about 2 days, but soon is too much affected by the feeding parasites and ultimately dies, but not before the parasite larvae finish their feeding and become full grown which is 3 to 4 days. As the parasites have remained in the same position, they become a heaped-up mass of fat maggot-like creatures. They

then separate and spin flimsy, more or less cocoon-like structures beneath the dead caterpillar thus fastening it to any object on which it may be resting. The change to the pupa stage, and eventually to adults, takes place here. The length of time for this development is 6 to 9 days, usually 7 or 8 days. The whole time from egg to maturity is thus 12 to 16 days, a very short period for the life cycle, and allows for about 20 to 25 generations per year. The adults live for about a month and must produce a large number of eggs individually; a record of one female living but two weeks was 213 eggs.



EUPLECTRUS PLATYHYPENAE

A Mexican armyworm parasite which has been introduced and widely distributed in an effort to control armyworms.

Soil Acidity: Its Relation to Root-rot*

By W. T. McGEORGE.

The practice of liming in agriculture is, we might say, as old as agriculture itself. In spite of this fact the crude rule-of-thumb methods have been the rule up to a comparatively recent period. During the latter part of the last century an acid or sour condition was recognized in soils and we note the use of lime as a sour soil amendment. ^AIt was noted that most crops grew best in the complete absence of acidity or in very faintly acid soils. Poor growth under this highly acid environment was attributed to the acidity itself. For quite an extensive period this theory was accepted and we find numerous attempts to determine the lime requirement of crops and soils. ^X While some of these merited consideration, in general, there resulted principally confusion out of which we are at last coming to understand soil acidity with greater clearness.

It has practically always been recognized that alkali soils contain alkaline salts in solution. The alkaline reaction of these soil types was considered secondary to the toxic effect of the alkaline salts themselves on plants. Acid soils are now being studied from this same angle and the presence of toxic acid salts in such soil types has been definitely proven. Among the compounds present in acid soils, which are notably absent in alkaline soils, the salts of iron, aluminum and manganese are of greatest significance. There has been a great deal of time devoted, in agricultural research, to investigations dealing with the effect of the salts of these elements upon plant growth. Much of this work had been done previous to the association of their presence in acid soils with poor growth. It is beyond the scope of this report to deal with this phase of the problem. Suffice it to say that there is a great deal of contradictory evidence which indicates that the influence of these elements upon plant growth must be studied with reference to each plant type of itself. ^{*}

In a study of the factors associated with the so-called Lahaina disease, which for the past twenty years or more has been of no small concern to the sugar planters, the question arose as to the presence of the salts of these elements in the soil solution of Hawaiian soils and their association with the low vitality of sugar cane. While the root-rot or Lahaina disease of sugar cane has been partially solved through the substitution of more resistant varieties it still exists and in some localities does affect the growth of the more resistant varieties. The root-rot problem has, however, been further aggravated by the appearance of the so-called pineapple wilt which appears more serious in the absence of suitable resistant varieties which can be substituted for the Smooth Cayenne. This variety, it appears, cannot be equalled in its adaptability to local environment.

In previous investigations there has been assumed a more or less close relation between pineapple wilt and Lahaina disease. There are unquestionably

* Read at the Pineapple Short Course, University of Hawaii, March 26, 1924.

a number of points of similarity. It is not within the limits of this paper to review the past work except to state that as yet no definite proof has been obtained nor any definite identification of a toxic soil constituent or organism associated with these two diseases, if diseases they are.

In planning the investigations which are now being conducted, a casual survey of the situation strongly indicated the following points. √ Root-rot is probably not the result of the same factor or factors in all cases. For example, we find sugar cane root-rot on a wide variety of soil types, climatic environment, altitude and locality. And I think the same may be said to apply to the pineapple plant with probably less variable conditions than those under which sugar cane root-rot, or might we better say plant failure, obtains. Also evidence and observations collected in the last twenty years strongly point toward the location of the toxic factors in the soil. ×

In view of the fact that the more resistant varieties have shown evidences of root-rot in our upland soils these soil types have been given first consideration. The principal characteristics of our upland soils are their acidity and phosphate deficiencies with occasional deficiencies in potash. On this basis the first phase of our work was to determine what factors associated with acid soils produce the toxicity toward plant roots. While this investigation has dealt specifically with cane roots the results are of considerable interest to the pineapple industry on account of the large acreage of upland soils cropped to this fruit.

As previously mentioned, a number of investigators in the field of soil fertility have associated salts of iron, aluminum and manganese with the low root vitality of crops grown on acid soils. √ Among these may be mentioned the Experiment Stations in Indiana, Massachusetts, New Jersey, Rhode Island and the Bureau of Plant Industry, U. S. Department of Agriculture. Of these Indiana is probably the pioneer. In 1913, they published a bulletin setting forth their researches upon a certain acid soil on which corn root-rot was prevalent and which responded to phosphates without any neutralization of acidity. It was very evident from this that the acidity itself was not the toxic constituent of this soil, at least when cropped to corn and further that phosphate had removed the toxic constituent which they believed to be aluminum. Iron and manganese are closely associated with aluminum in properties and have been linked with this element as being contributory factors in the toxicity of acid soils. ✓

In order that you may understand the association of soluble salts of these elements with acid soils, it is necessary to discuss briefly the properties of the salts of these elements. When we dissolve a salt of any of these elements in water (water itself is neutral in reaction) it will undergo a change which is known in chemical terms as hydrolysis. The result is the formation of an acid through chemical exchanges between the elements making up water and the salt. That is, for example, whenever we find chloride of aluminum in solution in water the solution is acid. The question arises what soils contain soluble salts of these elements?

We have only recently completed a very careful study of the acid island soils which clears up this point. On the basis of this work it is now only necessary to determine the soil reaction in order to definitely establish the presence or absence of these acid salts. In determining the reaction we have available two

methods, namely, the hydrogen electrode or the use of indicators. A brief explanation may be essential at this point.

The old methods of determining the lime requirement of soils have, in a large measure, been supplanted by the use of what we term the pH scale. This, to the practical field man, may appear a mysterious term, yet, in fact, it is the personification of simplicity. On this scale we take pure water which is neutral in reaction and assign to it the value pH 7.0. Points on the scale above 7.0 are applied to alkaline soils. Island soils rarely go above 8.0, the coral lands being our most alkaline types. Mainland soils containing black alkali run much higher. Points on the scale below 7.0 are applied to acid soils, increasing acidity being indicated by the lowering points on the scale. Our most acid soils are usually slightly above 4.0.

Our first problem then was to determine the presence of aluminum and its associated salts in our acid soils and the reaction at which it is possible to have these acid salts present. For this work we chose a series of soils ranging in pH from 4.2 to 8.0. The actual soil solution was removed from each and in this solution the soluble salts separated from the colloidal forms. It was found that all soils below a pH of 5.8, or very close to this point, contained acid salts of iron, aluminum and manganese in solution while those above this point did not. It should be remembered in this connection that the soils between pH 5.8 and 7.0 are acid. In other words an acidity of pH 5.8 or greater is an essential factor. This applies to the salts of manganese as well as aluminum and it is interesting to note in this connection that we have yet to find a highly manganiferous soil with manganese in the soil solution. The pH on all samples of this type are above 5.8 and the manganese is present only in forms insoluble in the soil solution.

Having established beyond question the presence of these acid salts in Hawaiian soils, what of their action upon root growth? In an extensive series of water, sand and soil cultures we have proven a high degree of toxicity in aluminum salts toward cane roots. Manganese salts, while they appeared to effect a slight disturbance in the leaves, are apparently without influence upon the roots. Iron salts, our results indicate, may be entirely disregarded as being a factor unless probably in our poorly aerated types where we have ferrous forms present. Sugar cane roots in the presence of aluminum first give indications of distress by a curling or fish-hooked appearance on the root tips. Later the root hairs, the feeding roots in other words, weaken, rot and drop off the main roots.

Whether or not aluminum salts are toxic toward pineapple roots has as yet not been definitely determined. It is, however, definitely certain that pineapple wilt is widely prevalent on acid soils in which we have found aluminum and manganese salts in abundance. Among such districts may be mentioned Kapaa, Kauai, and the Kaneohe district on Oahu.

The correction of aluminum toxicity in acid soils is a very simple procedure although in some cases not entirely economical. The theory itself is simple, two methods being at our disposal. We may lime the soil to a reaction range sufficient to bring it within the range at which aluminum salts are insoluble, or we may add superphosphate which will combine with the aluminum to form the insoluble aluminum phosphate. The toxic action of aluminum on the plant is not definitely understood. I will, therefore, avoid a discussion of the several theories

except to state that it does not appear to be a direct toxic action but rather produces a phosphate deficiency in the plant. In some cases response has not been obtained either with liming or phosphate but only after satisfying a potash deficiency also. In other words, where the plant is properly nourished aluminum seems to have little or no toxic effect and we have proven this point in the nutrition of sugar cane by growing in cultures with the roots divided; that is, half of the roots growing in a strong aluminum solution and half in a well balanced nutrient. >

In applying these corrective theories in soil pot cultures using 40 pounds soil per pot we have obtained wonderful stimulation of root growth and tops as well from phosphate applications. Lime, thus far, has proven less effective. The latter point was rather expected but is being given further study for therein lies the most economical solution of the problem. It is believed that the action of the lime is very much slower and that it may take several years to function and also that it will require the determination of the associated deficiency of potash or phosphoric acid. The action of the phosphate is immediate but very heavy applications are necessary and in view of the fact that it does not change the reaction of the soil it is only a matter of time until we will again have soluble aluminum present as the potential supply is unlimited. x

During the course of our investigations two observations were suggestive of possible application to the pineapple planters. I have reference in the one case to the fact that we found that even though one-half of the sugar cane roots were growing in a solution of aluminum, if the other half were drawing nutrients from a well balanced nutrient solution the plant seemed to grow normally. This suggests the possibility of stimulating the pineapple plants on acid soils by supplying the deficiency of potash or phosphoric acid through the medium of the roots encircling the stalk at the base of the leaves. In the other case, in view of the fact that lime applications are productive of chlorotic leaves it is suggested that crude potassium carbonate may be substituted for lime as a neutralizer of acidity at the same time supplying potash as plant food to the plant.

In order that you may correctly interpret the preceding discussion I will state that it is not the intention to convey to you or to claim, a solution of the pineapple wilt problem but rather to present to you one phase of our soil studies on the factors associated with sugar cane root-rot which appears also to be associated with pineapple wilt. It is my belief that your wilt problem will, like our own root-rot problem, be found to be due to a number of different factors separately or together. I base this statement on my impression that the so-called wilt may be found on a number of widely varying soil types and we naturally expect to find different factors contributing under such conditions. I do, however, firmly believe that aluminum and manganese salts are the principal contributory factors on all pineapple soils with a pH lower than 5.8 and your acreage planted on such types is extensive.

Measurement of Irrigation Water

RULES FOR SUBMERGED ORIFICE INSTALLATION.

By R. J. LYMAN.

The flow of water through an orifice has been found to conform closely to the formula :

$$Q = C \overline{A \sqrt{2 gh}}$$

Q = Cubic feet per second, or sec. ft.

C = Coefficient (value usually between .61 and .70).

A = Area of orifice in sq. ft.

g = Acceleration of gravity (or 32.16).

h = Pressure head in feet.

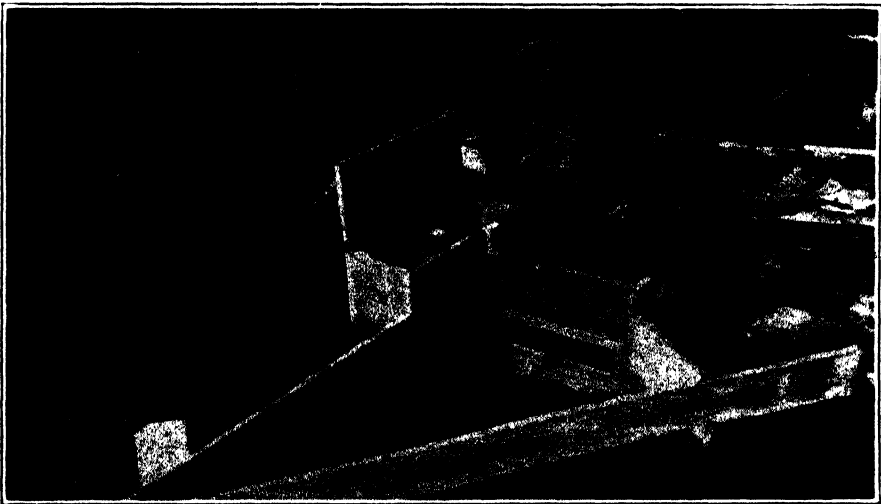


Fig. 1. Above picture shows the installation of a $\frac{3}{4}$ square foot orifice and a Great Western submerged orifice meter on the Hawi Mill, Kohala District.

The water flows through the orifice because of the pull of gravity, and the speed with which it flows is dependent principally on the pressure head. These two factors are, therefore, associated under the square root radical. Gravity is not 100 per cent effective, however, in its pull on the water. In fact it is only about 16 per cent effective. The effectiveness has been found by experiment to be in proportion to the factor $\sqrt{2 gh}$ for different pressure heads, but the product from this factor gives an effectiveness of 25 per cent on the average. Hence, the final product must be reduced by a multiplier the value of which should be .64 in this case to equal 16 per cent.



Fig. 2. Shows the same installation after the water has been turned on.

This is the explanation of the origin of the coefficient value. This coefficient value will vary according to the installation conditions. For ordinary conditions its value will range from .62 to .65. It may be stated here that conditions sur-

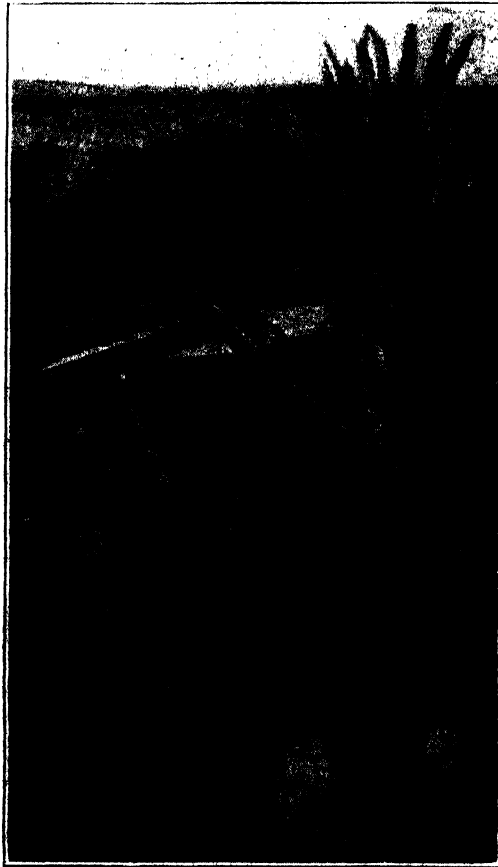


Fig. 3. The same installation as shown in cuts one and two. Note the check board about eight feet below the orifice, which insures submergence of the orifice opening.

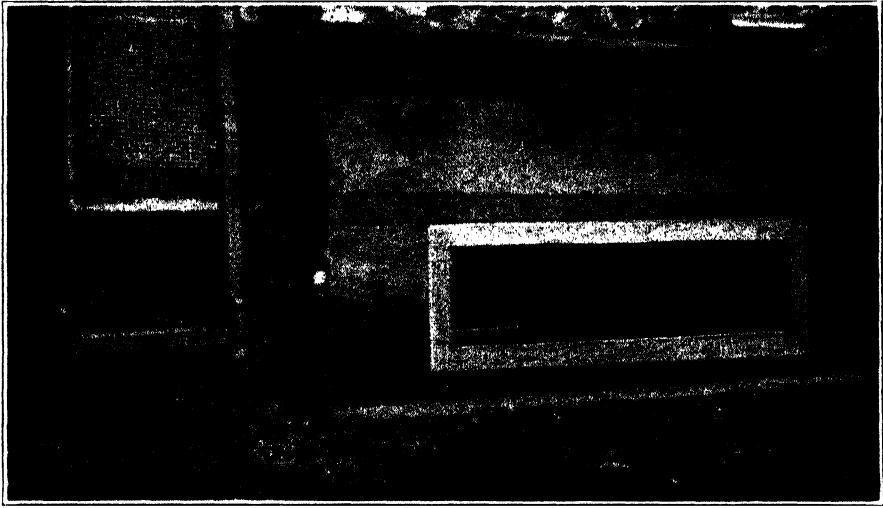


Fig. 4. An orifice and meter installation on the Ewa Plantation. The screens on the left are elevated to show the intake to the meter chamber.

rounding a weir installation may cause a larger variation from the standard weir formula than this. It may be well to also call attention at this point to the fact that the weir formula of discharge is fixed, whereas the orifice formula is flexible and may be adapted to any flow conditions.

The variability of factor C is due to conditions surrounding the installation. If an orifice is larger than $1/10$ the area of the channel of approach the coefficient will tend to be higher than .62. If the bottom contraction is low (less than 6" for a 12" [vertical] orifice) the coefficient will be higher than .62. If the orifice is not flush with the upper face of the structure but is set in the box a few inches down from the face a velocity of approach will develop before the water reaches the orifice. The coefficient will be slightly higher for increasing sizes of orifices. However, the coefficient for an orifice 12" by 84" will be very



Fig. 5. Another orifice and meter installation on the Ewa Plantation. Mr. J. M. Watt is in charge of installation at the Ewa Plantation.

little higher than for a 12" by 12" opening, providing the same proportionate channel of approach conditions prevail.

The following general rules for orifice installation may therefore, be stated:

1. For orifice areas under 5 sq. ft. the area of the channel of approach should be 6 to 10 times the orifice area. Quietness of approach of the water to the orifice is the principal factor in the accuracy of measurement.

2. The approach basin should extend 12 to 20 feet up stream from the structure.

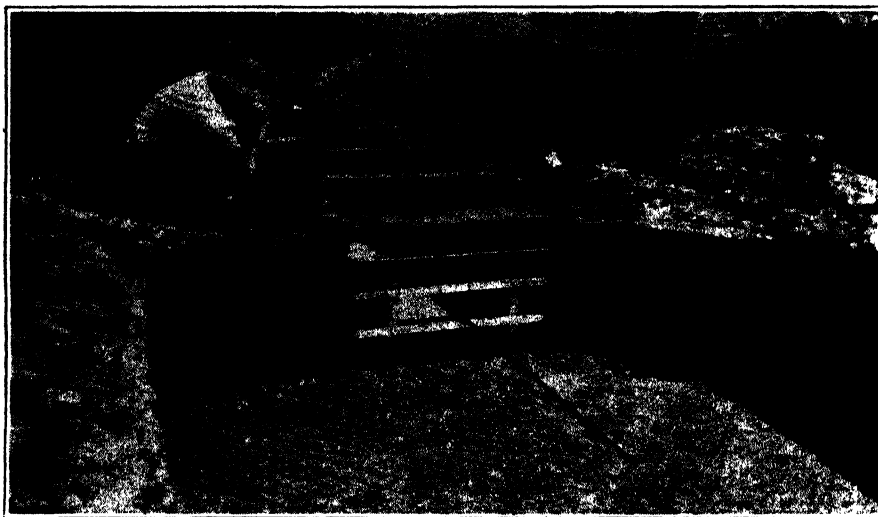


Fig. 6. A square foot orifice installation on the Ewa Plantation. Note the large approach basin above the orifice, which insures uniform accuracy.

3. The water must be made to flow at a right angle and with the principal velocity in the center in approaching the orifice.

4. The orifice should be flush with the upper face of the box to obtain all the side contraction possible.

5. The box should be at least 2 feet wider than the orifice length.

6. An oblong orifice is to be preferred to a square one.

7. The orifice edge should be lined with metal. The edges should project at least $\frac{3}{8}$ " from the frame.

8. As the formula of discharge applies to a submerged orifice it is necessary to keep the orifice under water at all times. A check board may be required to accomplish this. This check board should be located far enough down stream so as not to interfere with the orifice flow.

9. With each orifice installation a pair of connected wells above and below the orifice at one side should be provided to obtain accurately the pressure head acting on the orifice.

The following is a table of discharge for 1 sq. ft. to 5 sq. ft. orifices in sec. ft. and million gals. per 24 hrs. (based on coefficient .63):

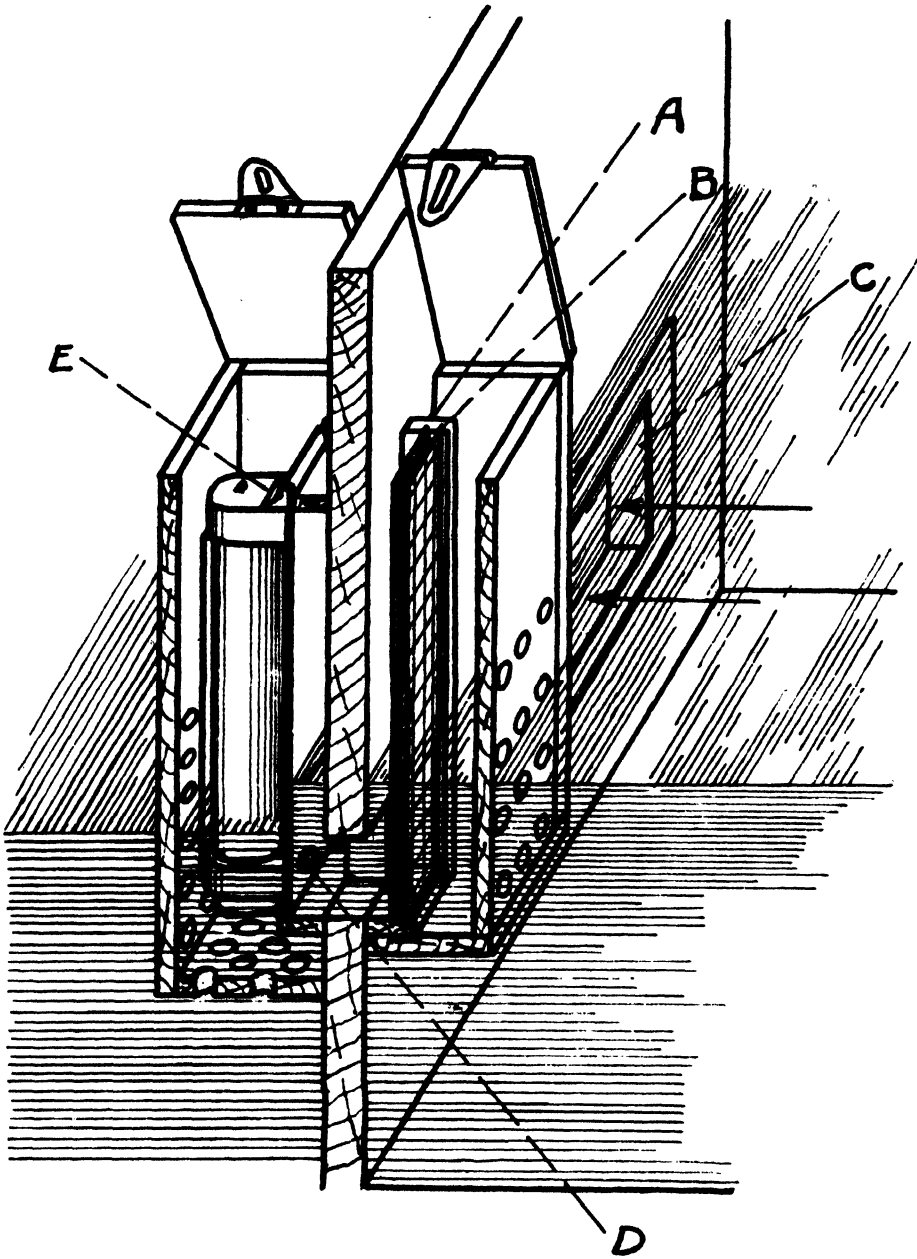


Fig. 7. Above is a sectional view of a Great Western orifice meter installation, shown as if cut through the orifice board and the boxes used to protect the meter and screens.

The main flow of water is in the direction of the arrows through the submerged orifice "C." A small proportion of the water flows through the screens "B" and "A," and enters the meter through hole "D," rotating the meter turbine at a speed dependent on the pressure head (or difference in water levels between inlet and outlet.)

The meter is geared to compute the water flowing through the main orifice in acre feet, which may be read directly at "E."

Orifice area Head In feet	1 sq. ft.		2 sq. ft.		3 sq. ft.		4 sq. ft.		5 sq. ft.	
	Sec. Ft.	Mil. Gals.	Sec. Ft.	Mil. Gals.	Sec. Ft.	Mil. Gals.	Sec. Ft.	Mil. Gals.	Sec. Ft.	Mil. Gals.
.03	.88	.56	1.75	1.13	2.63	1.70	3.50	2.26	4.38	2.83
.04	1.01	.65	2.02	1.30	3.03	1.96	4.04	2.61	5.05	3.26
.05	1.13	.73	2.26	1.46	3.39	2.19	4.52	2.92	5.65	3.65
.06	1.24	.80	2.48	1.60	3.71	2.39	4.95	3.20	6.19	4.00
.07	1.34	.87	2.67	1.72	4.01	2.58	5.35	3.46	6.68	4.32
.08	1.43	.92	2.86	1.84	4.29	2.77	5.72	3.69	7.14	4.60
.09	1.52	.98	3.03	1.95	4.55	2.94	6.06	3.91	7.58	4.89
.10	1.60	1.04	3.20	2.06	4.79	3.10	6.39	4.13	7.99	5.15
.12	1.75	1.13	3.50	2.26	5.25	3.39	7.00	4.52	8.75	5.65
.14	1.89	1.22	3.78	2.44	5.67	3.66	7.56	4.88	9.45	6.10
.16	2.02	1.30	4.04	2.61	6.06	3.91	8.08	5.22	10.10	6.52
.18	2.14	1.38	4.28	2.76	6.43	4.15	8.57	5.53	10.72	6.92
.20	2.26	1.45	4.52	2.91	6.78	4.37	9.04	5.84	11.30	7.30
.22	2.36	1.53	4.72	3.05	7.08	4.57	9.44	6.10	11.80	7.62
.24	2.47	1.60	4.94	3.20	7.41	4.78	9.88	6.39	12.35	8.00
.26	2.58	1.67	5.16	3.33	7.74	5.00	10.36	6.69	12.90	8.32
.28	2.67	1.72	5.34	3.45	8.01	5.13	10.68	6.89	13.35	8.61
.30	2.77	1.79	5.54	3.58	8.31	5.37	11.08	7.16	13.85	8.94
.32	2.86	1.85	5.72	3.69	8.58	5.54	11.44	7.38	14.30	9.22
.34	2.95	1.90	5.90	3.81	8.85	5.70	11.80	7.60	14.75	9.52
.36	3.03	1.96	6.06	3.91	9.09	5.87	12.12	7.82	15.15	9.77
.38	3.11	2.01	6.22	4.02	9.33	6.02	12.44	8.02	15.55	10.01
.40	3.20	2.07	6.40	4.13	9.60	6.20	12.80	8.26	16.00	10.32
.42	3.27	2.11	6.54	4.22	9.81	6.33	13.08	8.44	16.35	10.55
.44	3.35	2.16	6.70	4.33	10.05	6.49	13.40	8.65	16.75	10.80
.46	3.43	2.21	6.86	4.42	10.29	6.65	13.72	8.86	17.15	11.10
.48	3.50	2.26	7.00	4.52	10.50	6.78	14.00	9.04	17.50	11.30
.50	3.57	2.31	7.14	4.60	10.71	6.92	14.28	9.20	17.85	11.51
.52	3.64	2.35	7.28	4.70	10.92	7.06	14.56	9.40	18.20	11.72
.54	3.71	2.40	7.42	4.78	11.13	7.19	14.84	9.57	18.55	11.97
.56	3.78	2.45	7.56	4.88	11.34	7.32	15.12	9.76	18.90	12.20
.58	3.86	2.49	7.72	4.98	11.58	7.46	15.44	9.97	19.30	12.45
.60	3.91	2.53	7.82	5.04	11.73	7.57	15.64	10.09	19.55	12.61
.62	3.98	2.57	7.96	5.14	11.94	7.70	15.92	10.28	19.90	12.83
.64	4.04	2.61	8.08	5.22	12.12	7.82	16.16	10.40	20.20	13.03
.66	4.10	2.65	8.20	5.29	12.30	7.94	16.40	10.58	20.50	13.22
.68	4.17	2.69	8.34	5.38	12.51	8.07	16.68	10.78	20.85	13.44
.70	4.23	2.73	8.46	5.46	12.69	8.18	16.92	10.92	21.15	13.62
.72	4.29	2.77	8.58	5.53	12.87	8.30	17.16	11.08	21.45	13.84
.74	4.35	2.81	8.70	5.61	13.05	8.42	17.40	11.22	21.75	14.00
.76	4.40	2.84	8.80	5.68	13.20	8.51	17.60	11.36	22.00	14.20
.78	4.46	2.88	8.92	5.76	13.38	8.64	17.84	11.50	22.30	14.38
.80	4.52	2.92	9.04	5.83	13.56	8.75	18.08	11.65	22.60	14.58
.82	4.58	2.96	9.16	5.91	13.74	8.87	18.32	11.80	22.90	14.78
.84	4.63	2.99	9.26	5.97	13.89	8.96	18.52	11.95	23.15	14.92
.86	4.69	3.03	9.38	6.06	14.07	9.07	18.76	12.10	23.45	15.13
.88	4.74	3.06	9.48	6.13	14.22	9.18	18.96	12.22	23.70	15.30
.90	4.80	3.10	9.60	6.20	14.40	9.30	19.20	12.39	24.00	15.50
.92	4.85	3.13	9.70	6.26	14.55	9.39	19.40	12.50	24.25	15.62
.94	4.90	3.16	9.80	6.32	14.70	9.50	19.60	12.62	24.50	15.80
.96	4.95	3.20	9.90	6.38	14.85	9.58	19.80	12.75	24.75	15.95

Orifice area	1 sq. ft.		2 sq. ft.		3 sq. ft.		4 sq. ft.		5 sq. ft.	
Head	Sec.	Mil.	Sec.	Mil.	Sec.	Mil.	Sec.	Mil.	Sec.	Mil.
In feet	Ft.	Gals.	Ft.	Gals.	Ft.	Gals.	Ft.	Gals.	Ft.	Gals.
.98	5.00	3.23	10.00	6.46	15.00	9.69	20.00	12.90	25.00	16.13
1.00	5.05	3.26	10.10	6.52	15.15	9.76	20.20	13.02	25.25	16.30
1.05	5.17	3.34	10.34	6.68	15.51	10.00	20.68	13.33	25.85	16.68
1.10	5.39	3.42	10.78	6.95	16.17	10.40	21.56	13.90	26.95	17.38
1.15	5.41	3.49	10.82	7.00	16.23	10.48	21.64	13.97	27.05	17.50
1.20	5.53	3.58	11.06	7.14	16.59	10.69	22.12	14.27	27.65	17.82
1.25	5.64	3.64	11.28	7.28	16.92	10.91	22.56	14.53	28.20	18.20
1.30	5.76	3.72	11.52	7.44	17.28	11.14	23.04	14.87	28.80	18.58
1.35	5.87	3.79	11.74	7.57	17.61	11.35	23.48	15.14	29.35	18.95
1.40	5.98	3.86	11.96	7.72	17.94	11.58	23.92	15.40	29.90	19.30
1.45	6.09	3.92	12.18	7.86	18.27	11.79	24.36	15.70	30.45	19.63
1.50	6.19	3.99	12.38	8.00	18.57	11.98	24.76	16.00	30.95	19.96

Note: Millions of gallons per 24 hours is .646 of second feet.

Cultivation Practices

By J. A. VERRET.

Our attention was recently called to an article in the "Country Gentleman," March 29, 1924, entitled "Why do we Plow?" It is a very interesting article and will repay reading by all engaged in the raising of crops.

For some years now we have been conducting experiments here in an endeavor to answer this question for Hawaiian conditions. We shall give herewith a review of the results obtained, rather than attempt to give a theoretical discussion as to whether we should plow or not. As the years go by, we are losing more and more of our pet theories, and the demand is more and more for actual results before forming conclusions.

The results to be reported will refer particularly to the use of plows in fields with growing crops, and not to the preparation of the seed bed before planting. The two subjects are distinct and require separate studies.

We still believe it pays to make as good a job as we know how in preparing a field before planting. In doing this, special effort should be made to destroy as many weeds and weed seeds as possible, rather than do it with hoes after the cane is growing.

This may well be the most important function of seed bed preparation; that, and the thorough stirring and aeration of the soil with its exposure to sunlight for several weeks.

Summary of Experimental Results: The first cultivation experiment conducted by the Station was at Oahu Sugar Company, in Field 6, 1913 crop. The results were as follows and show no gain:

Cultivation = 61.3 tons of cane per acre.

No cultivation = 61.4 tons of cane per acre.

The next experiment to be put in was at Waipio, in Section F, for the 1916 and 1917 crops. Since that time we have harvested cultivation experiments every year.

The results obtained from these various tests are herewith summarized:

WAIPIO EXPERIMENT F, 1916 CROP

Treatment	Cane	Tons per Acre	
		Q. R.	Sugar
Cultivation (hilling)	78.8	7.52	10.47
No cultivation	77.2	7.51	10.27

WAIPIO F, 1917 CROP

Treatment	Cane	Tons per Acre	
		Q. R.	Sugar
Cultivation (hilling)	44.3	9.06	4.89
No cultivation	45.5	8.75	5.20

WAIPIO EXPERIMENT M, 1917 CROP

Treatment	Cane	Tons per Acre	
		Q. R.	Sugar
Hilled	37.4	7.54	4.96
Not hilled	37.5	7.54	4.97

HILO EXPERIMENT 8, 1918 CROP

5 plots—Off-barred.....	38.7	tons of cane per acre		
5 plots—Off-barred and stools split.....	35.9	" " " "		
5 plots—Off-barred.....	29.4	" " " "		
5 plots—Stools split.....	28.0	" " " "		

PAAUHAU SUGAR PLANTATION EXPERIMENT 8, 1918 CROP

No. of Plots	Treatment	Cane	Tons per Acre	
			Q. R.	Sugar
4	Off-barring, middle breaking, hilling.....	38.0	8.64	4.39
4	Weeding with hoes only.....	40.3	8.53	4.72

PAAUHAU SUGAR PLANTATION EXPERIMENT 9, 1918 CROP

No. of Plots	Treatment	Cane	Tons per Acre	
			Q. R.	Sugar
3	Off-barred	37.2	8.38	4.44
3	Not off-barred	34.9	8.33	4.19

WAIPIO EXPERIMENT B, 1918 CROP

No. of Plots	Treatment	Cane	Tons per Acre	
			Q. R.	Sugar
36	Hilled	89.2	10.09	8.84
36	Not hilled	88.7	10.06	8.83

HILO SUGAR COMPANY EXPERIMENT 14, 1919, 1921 AND 1923 CROPS

Treatment	Tons Cane per Acre			Avg.	Avg. Tons
	1919	1921	1923	Q. R.	Sugar per Acre
Hilled	57.0	66.8	51.9	7.88	7.44
Not hilled	60.7	68.4	51.2	7.75	7.77

HILO SUGAR COMPANY EXPERIMENT 15, 1919 AND 1923 CROPS

Treatment	Tons Cane per Acre		Avg.	Avg. Tons
	1919	1923	Q. R.	Sugar per Acre
Off-barred, hilled, etc.	55.6	51.7	8.02	6.70
Not off-barred, hilled, etc.	56.2	55.4	7.99	6.98

HILO SUGAR COMPANY EXPERIMENT 16, 1919, 1921 AND 1923 CROPS

Treatment	Tons Cane per Acre			Avg.	Avg. Tons
	1919	1921	1923	Q. R.	Sugar per Acre
Off-barred	57.1	60.7	49.3	8.28	6.73
Not off-barred	59.4	62.0	53.0	8.04	7.23

HAKALAU CULTIVATION EXPERIMENT 1920 CROP (Conducted by the Plantation)

Treatment	Tons per Acre		
	Cane	Q. R.	Sugar
Off-barring, middle-breaking, hilling-up, etc.	40.7	7.93	5.14
Not off-barred—all others same as above.	42.0	7.46	5.63
No animal work, weeding and covering fertilizer with hoes.	44.1	7.37	5.98

ONOMEA SUGAR COMPANY EXPERIMENT 10, 1921 CROP—STUBBLE SHAVING

Treatment	Tons per Acre		
	Cane	Q. R.	Sugar
Stubbles shaved	41.6	7.79	5.34
Not shaved	41.5	7.44	5.58

McBRYDE EXPERIMENT 6, 1921 CROP

Hilled = 43.6 tons cane per acre.

Not hilled = 37.8 tons cane per acre.

HAKALAU EXPERIMENT 11, 1922 CROP

Treatment	Tons per Acre		
	Cane	Q. R.	Sugar
Plows, off-barring, hilling, etc.	51.7	8.12	6.36
Cultivators (no plows)	52.7	8.00	6.59
Hoes only	50.0	7.86	6.37

HAKALAU EXPERIMENT 12, 1922 CROP

Treatment	Tons per Acre		
	Cane	Q. R.	Sugar
Plows, off-barring, hilling, etc.	38.8	8.25	4.70
Cultivators (no plows)	36.8	7.99	4.61
Hoes only	40.1	8.07	4.96

HALAWA PLANTATION EXPERIMENT 1, 1922 CROP

Treatment	Tons per Acre		
	Cane	Q. R.	Sugar
Plows, off-barring, hilling, etc.....	29.8	8.07	3.70
Cultivators (no plows).....	29.3	8.01	3.65
Hoes only	29.0	8.09	3.59

HAMAKUA EXPERIMENT 6, 1922 CROP

Treatment	Tons Cane per Acre		
Plows, off-barring, hilling, etc.....	23.7		
Cultivators (no plows).....	24.1		
Hoes only	23.6		

ONOMEA EXPERIMENT 12, 1922 CROP

Treatment	Tons per Acre		
	Cane	Q. R.	Sugar
Plows, off-barring, hilling, etc.....	50.1	10.18	4.92
Hoes only	54.0	9.73	5.55

HAWI MILL & PLANTATION COMPANY EXPERIMENT 3, 1923 CROP

Treatment	Tons per Acre		
	Cane	Q. R.	Sugar
Off-barred with 6" plow.....	12.7	8.34	1.55
Off-barred with 10" plow.....	13.8	8.77	1.57
Off-barred with 12" plow.....	13.9	8.51	1.63
Average all off-barred.....	13.5	8.54	1.58
Not off-barred	13.2	8.58	1.53

ONOMEA SUGAR COMPANY EXPERIMENT 13, 1924 CROP

Treatment	Tons per Acre		
	Cane	Q. R.	Sugar
Plows, off-barring, hilling, etc.....	62.5	9.15	6.83
Cultivators (no plows).....	65.1	9.05	7.19
Hoes only	68.0	8.96	7.58

For convenient reference the experiments listed above are tabulated below giving the tons of sugar per acre for each treatment:

Plantation	Experiment No.	Crop Year	Cultivators			Loss or Gain From Plows
			Plows	No Plows	Hoes Only	
Paaupau	8	1918	4.39	....	4.72	loss
Hilo Sugar Co.	15	1919	8.04	....	7.99	equal
Hilo Sugar Co.	15	1923	5.37	....	5.88	loss
Hakalau . . . . .	..	1920	5.14	5.63	5.98	loss
Hakalau	11	1922	6.36	6.59	6.37	equal
Hakalau	12	1922	4.70	4.61	4.96	loss
Halawa Plantation	1	1922	3.70	3.65	3.59	gain
Hamakua Mill	6	1922	2.96*	3.01*	2.95*	equal
Onomea	12	1922	4.92	....	5.55	loss
Onomea	13	1924	6.83	7.19	7.58	loss
Avg. of 10 experiments (plows vs. hoes).....			5.24	....	5.55	loss
Avg. of 6 experiments (plows vs. cultivators, hoes)			4.95	5.11	5.24	loss

* Estimated from cane yields at 8 quality ratio.

In the above experiments where plows, cultivators and hoes are compared, we find that of the ten tests, six show a loss from plowing, three show no difference and one a gain. This single gain is small, amounting to less than one ton of cane per acre and about 0.10 ton of sugar.

EXPERIMENTS HAVING TO DO WITH OFF-BARRING ARE LISTED AS FOLLOWS:

Plantation	Experiment No.	Crop Year	Off-barr'd	Not Off-barr'd	Gain or Loss From Off-barring
Paaauhau	9	1918	4.44	4.19	gain
Hilo Sugar Co.	16	1919	8.12	7.99	gain
Hilo Sugar Co.	16	1921	7.45	8.12	loss
Hilo Sugar Co.	16	1923	5.10	5.86	loss
Hawi Mill	3	1923	1.58	1.53	equal
Average			5.34	5.54	

In five experiments we find that two gave a gain from off-barring, two gave a loss and one showed no difference. The average results show a loss of 0.20 ton of sugar per acre from off-barring.

RESULTS FROM HILLING ARE SUMMARIZED:

Plantation	Experiment No.	Crop Year	Hilled	Not Hilled	Gain or Loss From Hilling	
Oahu Sugar Co.	Field 6	1913	8.17*	8.17*	equal	Irrigated
Waipio	F	1916	10.47	10.27	gain	"
Waipio	F	1917	4.89	5.20	loss	"
Waipio	M	1917	4.96	4.97	equal	"
Waipio	B	1918	8.84	8.83	equal	"
McBryde	6	1921	5.81*	5.04*	gain	"
Hilo Sugar Co.	14	1919	8.33	8.79	loss	Not irrigated
Hilo Sugar Co.	14	1921	8.46	9.09	loss	"
Hilo Sugar Co.	14	1923	5.53	5.42	gain	"
Average			7.27	7.31		

Here in nine experiments, three show gains, three show losses and three give no difference from hilling. The gains in two of the tests are too small to be of consequence, being well within experimental error; on the other hand the losses are comparatively large.

The effect of plowing on the quality of the juices is indicated in the table given below:

* Estimated from cane tonnage at 7.5 quality ratio.

Plantation	Experiment	Crop Year	Quality Ratio		
	No.		Plows	Cultivators or Hoes	
Waipio	F	1916	7.52	7.51	—
Waipio	F	1917	9.06	8.75	—
Waipio	M	1917	7.54	7.54	=
Paaauhau	8	1918	8.64	8.53	—
Paaauhau	9	1918	8.38	8.33	—
Waipio	B	1918	10.09	10.06	—
Hilo Sugar Co.	14	1919	6.84	6.93	+
Hilo Sugar Co.	14	1921	8.00	7.53	—
Hilo Sugar Co.	14	1923	9.39	9.44	+
Hilo Sugar Co.	15	1919	6.91	7.03	+
Hilo Sugar Co.	15	1923	9.47	9.40	—
Hilo Sugar Co.	16	1919	7.03	7.44	+
Hilo Sugar Co.	16	1921	8.15	7.64	—
Hilo Sugar Co.	16	1923	9.67	9.05	—
Hakālau . . . . .	..	1920	7.69	7.37	—
Onomea Sugar Co.	10	1921	7.79	7.44	—
Hakalau	11	1922	8.06	7.86	—
Hakalau	12	1922	8.25	8.03	—
Halawa	1	1922	8.07	8.05	—
Onomea Sugar Co.	12	1922	10.18	9.73	--
Hawi Mill	3	1923	8.58	8.53	—
Onomea Sugar Co.	13	1924	9.15	9.00	—
Average	12		8.38	8.24	—

From the above list it appears that plowing has a tendency to slightly lower the quality of the cane juices. In a total of 22 tests, the plowed plots had better juices in four instances, no differences in one case. In the seventeen remaining ones the juices were poorer where plows were used. In other words, approximately six times out of seven, plowing gives a poorer juice. As before stated, the differences are small, but we believe they are significant just the same. These results are too consistent to be the outcome of chance.

Why plowing should cause this we are at a loss to explain. It may be that the root destruction by the plows, sometimes late in the season, delays the normal development of the plant, causes new root formation late, and thereby delays maturity. This is indicated by the results at Waipio where the largest juice differences are in short ratoons where the cane has less time to mature.

SUMMARY.

Of a total of 24 experiments where plowing was compared with surface cultivation of some sort for weed control, seven show a gain from plowing, eight show no difference and nine show a loss. An average of all the tests shows a loss of about 0.2 ton of sugar per acre when plows are used.

✓ This shows that, for average conditions, deep cultivation with plows in growing cane cannot be expected to raise the yield of sugar in itself. The benefits obtained come through weed control.

Our cultivation work must therefore be based on the most efficient methods of weed control with the least possible disturbance to the root systems

of the growing cane. If soil conditions are such that it is necessary to use plows, this should be done as early as possible, before the young cane has developed large root systems. Even then, one must know that there is some check as, until the new shoots have roots of their own they feed to some extent through the old root system by way of the old stumps, or, in plant, through the roots on the seed piece.

Results of the same nature as those obtained here are being gotten elsewhere. Some years ago, the U. S. Department of Agriculture conducted experiments, over one hundred in number, over a period of years, in about 30 different states to determine the best methods of cultivation for corn. They found no difference in the yield of corn between fields which were cultivated and those which were not, provided weeds were kept out.

In reporting the results of a cultivation experiment the Geneva Station, New York, says:

If the experiment has a meaning, it is that cultivation is not beneficial to the corn plant except so far as removing weeds is concerned. Strangely enough we have, during the existence of this Station, been unable to obtain decisive evidence in favor of cultivation.

Bud Selection as Affecting Quantity Production

By A. D. SHAMEL.

INTRODUCTION.

The importance and value of selection in seed propagated agricultural crops is no longer questioned and systematic seed selection has become an established practice as an efficient means for securing improved production.

The necessity for the selection of buds in vegetatively propagated crops has not been generally recognized until during comparatively recent years. In fact the importance of bud selection has often been questioned on account of a lack of experimental evidence proving its value and from the absence of any satisfactory explanation of the phenomenon of bud variation. The principles underlying seedling variation have been worked out and accepted in the case of many plants propagated from seed. The cause of bud variation is unknown and as yet no generally accepted explanation has been offered of the fundamental principles underlying the variability of vegetative cells. For these reasons and others, perhaps some observers have refused to recognize the fact of bud variation and have denied its importance in the propagation of horticultural and agricultural crops where the plants are propagated by budding, from cuttings, or through other vegetative means.

Within recent years a growing mass of experimental evidence and scientific observations have demonstrated beyond any question of doubt the occurrence of

striking and important bud variations in many important horticultural and agricultural plants which are commonly propagated from vegetative parts. The nature and frequency of the development of such bud variations in a number of food plants are now under investigation. While it is not possible to discuss the work as a whole at this time, a brief description of the methods of study used and some data illustrating typical results secured will be presented.

METHODS OF STUDY.

The study of the possibilities of bud selection for the improvement of production through the propagation of inherently superior parent plants involves an individual plant performance-record study as a basis for selecting parent plants for propagation and a progeny test of the selected plants in order to determine whether or not their characteristics are transmitted in propagation. In other words, the bud selection studies involve the selection of parent plants for propagation, based upon their performance records and the determination of their inherent characteristics through progeny tests. The writer believes that a natural inclination for and a sympathetic attitude toward this kind of work, together with an intimate knowledge of the plants with which they are working, gained through long continued first hand study and observation, are important qualifications for workers in this line of investigation.

The detailed methods for keeping individual plant performance records vary with the kind of plant under investigation, but in general it includes securing accurate data for a period of several consecutive and normal seasons of the quantity and quality of production. From the practical point of view, simplicity in number or kind of data used in individual plant performance-record work is of very great importance. The number, weight and grade of the individual plant's product, or other comparative units of measurement of yield, must be systematically secured in order to gain a reliable knowledge of individual plant behavior as a guide for selection. The habit of growth, season of maturity, resistance to disease or other adverse environmental factors of growth, and other plant characteristics are important considerations in the selection of individual plants for progeny tests. In the progeny test fields uniform land and favorable soil and cultural conditions are to be desired except where inherent disease or other resistance is to be studied.

IMPROVED YIELDS FROM SELECTION.

In order to illustrate the possibilities for securing improved yields through systematic bud selection work three recent and typical examples of achievements along this line will be described dealing with three important food crops, viz., potatoes, apples and oranges, all of which are commonly propagated vegetatively.

The work for the improvement of potatoes by hill selection described in this paper was reported by George Stewart in Bulletin No. 176, of the Utah Agricultural Experiment Station. This work was begun in 1911 with the selection of high and low yielding hills of the Bangor, Peerless and Majestic varieties. The selected hills were propagated in rows and the resulting crops were harvested as separate hills. In 1914, the Bangor and Peerless varieties were discarded on

account of their inferiority to the Majestic. Since 1914, only high-yielding hills have been selected in the crops of the Majestic progenies except in the case of a few strains possessing unusual foliage characteristics.

A comparison of the yields of the hill-selected Majestic potato crop with the crop grown from unselected stock is shown in the following table:

TABLE I.

Yields of Selected and Unselected Majestic Potato Crops for the Period of 1915-1920, Inclusive.

Year	Pedigree Selection Mg 25-1-9-20-3-15		Unselected Stock		Gain Over Unselected (bushels)
	Weight to the Hill (grams)	Acre- Yield (bushels)	Weight to the Hill (grams)	Acre- Yield (bushels)	
1915.....	1050.91	316.7	643.02	179.3	137.4
1916.....	839.40	330.7	583.70	191.2	139.5
1917.....	810.66	382.4	698.39	269.3	113.1
1918.....	771.57	311.9	580.11	202.4	109.5
1919.....	358.20	146.9	270.20	117.3	29.6
1920.....	962.12	353.4	517.60	184.8	168.6
Average.....	789.61	307.0	548.83	190.7	116.3

The progenies of the selected hills not only produced a much greater average yield than the crops from the unselected stock but the tubers in the progenies were of a larger average size than the tubers in the ordinary crop as shown in the following table:

TABLE II.

The Average Number of Tubers to the Hill and the Average Weight of Tubers for the Period of 1915-1919, Inclusive.

Year	Pedigree Selection Mg 25-1-9-20-3-15		Unselected Stock	
	Average No. Tubers to the Hill	Average Weight to the Tuber (grams)	Average No. Tubers to the Hill	Average Weight to the Tuber (grams)
1915	5.84	182.11	4.48	143.56
1916	4.58	184.20	3.84	152.80
1917	5.22	153.39	4.50	151.63
1918	4.10	187.43	4.49	127.87
1919	3.83	112.38	3.26	82.83
Average	4.89	163.90	4.14	131.74

It can be seen from an examination of these tables that during the period of 1915 to 1919 inclusive, hill selection has resulted in an increase of yield amounting on the average to 190.7 bushels of potatoes per acre. Selection has not only resulted in increased yields but has also produced larger individual tubers and a higher percentage of marketable potatoes than was found in the crop grown from comparative unselected stock.

This very interesting and significant study of the possibilities of hill selection for securing improved yields in potatoes by Professor Stewart indicates clearly and forcibly that bud variations in the potato includes those shown by the larger quantity of tubers in the individual hills, or plus variants, and that through the selection of the inherently productive hills higher yielding strains can be isolated and propagated. Not only do the higher yielding strains produce more tubers per acre but also potatoes of a larger and more desirable size and of higher commercial value than those from the unselected stock. From the practical standpoint this condition means more dollars per acre as a result of bud selection work.

The apple is one of the most widely grown fruit crops in America. The apple industry has become of very great commercial importance within comparatively recent times and a large number of farmers from Maine to California are now depending upon the growing of apples for a living. Therefore, any possibility of improving the production of apples through bud selection has a widespread and important application to the welfare of our horticultural interests. Furthermore, the apple has particular interest in this connection from the fact that most of the arguments against bud selection have been based upon the theory that no improvement in production through selection has been or can be effected with apple varieties.

The results of a well planned and consistently carried out study of bud selection in apples by the Central Experimental Farm of Ottawa, Canada, as reported by M. B. Davis, assistant horticulturist of that institution, in *Scientific Agriculture*, Vol. II, No. 4, pp. 120-124 inclusive, are of especial interest in considering the possibilities of selection for improved production.

The Central Experimental Farm has kept a record of the yield of individual apple trees since 1896. In 1906 scions were propagated from the heaviest yielding, the heaviest and most regular yielding and the lowest yielding trees of the Wealthy variety. The scions from the three parent trees were root-grafted on Rose of Stanstead and Dartmount Crab stock. From this propagation, progeny trees were secured as follows: 17 trees from the heaviest yielding, 12 trees from the heaviest and most regular yielding and 11 trees from the poorest yielding parent tree. The progeny trees were set out in the same orchard and under as uniform environmental conditions as possible.

The average yield of the parent trees for a period of 8 years and the average total yield of their progenies for their first 9 years of production is summarized in the following table:

TABLE III.

Average Yield of Parent Trees for a Period of 8 Years and Average Total Yield of Their Progenies for Their First 9 Years of Production Expressed in Terms of Gallons of Apples.

Rank of Parent Trees	Total Yield for 8 Years of Parent Trees	Rank of Progenies	Total Yield for 9 Yrs. of Progenies	Number of Trees in Progeny
Heaviest yielding	104¾ gallons*	Heaviest yielding	57.18 gallons	17
Most regular yielding	78¾ gallons	Most regular yielding	48.38 gallons	12
Poorest yielding	41 gallons	Poorest yielding	35.22 gallons	8

* The gallon here used is the English dry measure of capacity and equals one-eighth bushel.

The progeny of the heaviest yielding parent apple tree has produced on the average about 62 per cent more crop than the progeny of the poorest yielding parent tree, while the yield of the progeny of the heaviest and most regular parent tree has been intermediate. It will be noticed that the behavior of the progenies has been consistent with that of the parent trees.

This very important investigation indicates the possibility of securing larger and more profitable production in apple varieties by propagating from inherently productive parent trees. No difference in the quality of the fruits borne by the three parent trees or their progenies in this study is reported, so that in this case we have an instance of increase in quantity of production accomplished through selection. As the parent trees were propagated from buds in vegetative parts the inherent differences in behavior exhibited by the parent trees must have been due to bud variation. The progeny differences in production as shown in this table of yields are the results of bud selection and suggest the great and fundamental importance of this work to the apple grower in the profitable growing of apple crops.

The writer and his associates have, for a number of years, been carrying on a study of bud variations of citrus trees in California for the U. S. Department of Agriculture. Department bulletins describing some of the variations discovered and studied in the course of this investigation have been published. As a part of the work of this project as large a number of propagations have been made of some of these variations as circumstances permitted. For the most part these progeny tests are of bud variations exhibiting differences of commercial quality and quantity of fruit production. An important correlation of quality with quantity of fruit has been observed in that the larger production has usually been found to be correlated with superior commercial quality, while low production ordinarily has been correlated with undesirable size, shape, texture and other inferior characteristics of commercial quality. In order to illustrate the nature and importance of these progeny tests of citrus bud variations the results of one of the typical progeny tests will be presented. This particular experiment is concerned with a study of variations in quantity of fruit in trees of the Navel orange and their transmission through bud propagation.

In 1910, the writer discovered a tree of the Thomson strain of the Washington Navel orange variety in an orchard near his house which had one large unproductive branch, the other limbs bearing a normal quantity of fruit. This tree had been grown from a single bud on a sweet-orange seedling root-stock and was eight years old when first discovered. For several years the fruiting behavior of this tree was observed and the unproductive limb was found to be consistently unproductive while the remaining branches produced normal crops. The few fruits borne by the unproductive limb resembled those borne by the normal branches so closely that they could not be distinguished after picking. The blooming habit of the unproductive branch was apparently the same as that of the normal limbs but the foliage of the unproductive limb was more scant and the leaves were somewhat more pointed in shape than on the remainder of the tree. In other words, the difference between the behavior of the unproductive branch and the other limbs of this tree was apparently one of quantity of fruit

production. This difference in behavior was consistent year after year, but whether it was inherent or not had to be determined through a progeny test.

Three progeny trees grown from buds taken from the unproductive limb and two progeny trees grown from buds secured from one of the normal branches of the parent tree were planted in the Citrus Experiment Station orchard of the University of California at Riverside on July 2, 1917. These progeny trees were grown on sour orange root-stock and were planted ten feet apart in the orchard row, the three progeny trees of the unproductive branch being followed by the two progeny trees of the normal limb.

The performance records of the trees in this progeny test are given in the following table:

TABLE IV.

Performance Records of the Progeny Trees Propagated from an Unproductive Limb and from a Normal Branch of a Tree of the Thomson Strain of the Washington Navel Orange. The Trees were Budded in the Spring of 1915 and Planted July 2, 1917.

Season	Yield in Numbers of Fruits				
	Progeny of Unproductive Limb			Progeny of Normal Limb	
	Tree 1	Tree 2	Tree 3	Tree 4	Tree 5
1920-1921	1	3	0	18	50
1921-1922	0	0	0	61	60
1922-1923	0	0	1	56	72
Total number Fruits.	1	3	1	135	182

It will be seen that the three progeny trees of the unproductive limb have produced a total of only 5 fruits thus far as compared with a total of 317 oranges borne by the two progeny trees of the normal branch. A detailed statement regarding the behavior of progeny appears in the Journal of Agricultural Research for December 8, 1923.

The results of this and other similar progeny tests indicate clearly that in the citrus, inherent bud variations of quantity of fruit exist which are capable of perpetuation through budding. In these progeny tests not only unproductive but productive progenies as well have been propagated from limb variations, showing that plus as well as minus bud variants occur which, when propagated give rise to productive strains which yield an unusual proportion of uniformly high grade commercial fruits.

The importance and value of established and proven varieties for the growing of profitable crops can hardly be over-estimated. The results of the progeny tests referred to in this paper suggest that through systematic bud selection it is possible to conserve and improve these varieties through isolating and propagating productive strains arising from inherently superior bud variations.

Drainage Reclamation in the Western States by Small Pumping Plants

By GUY R. STEWART.

Irrigation has now been practiced in the Western States for a sufficiently long period to enable us to observe some of its after effects upon agricultural land. The tracts chosen for irrigation are nearly all alluvial plains or broad valleys where the land slopes gently towards the natural drainage channels. The rainfall in these semi-arid regions is light and variable so the natural drainage of the soil has not handled any large volume of percolating water.

The greater part of these western soils are light in texture so that it would appear that excess water would move through such soils with great ease. The low rainfall has not been sufficient, however, to remove all the salts which have been formed in every soil as the result of the gradual decomposition of the rock minerals. In some cases the lime salts have been concentrated to form a calcareous hardpan, in others the sodium salts have been partly leached out and have then collected in the lower lands as alkali patches. In still other instances, the salts are distributed through the upper or lower layers of the soil in very small amounts.

With the application of irrigation water to such land an entirely new set of conditions comes into effect. Practically all the early projects have first distributed the water through unlined main ditches and laterals. This has resulted in heavy seepage losses ranging from 10 per cent up to 50 per cent or higher. Many irrigators of arid land have habitually used excessive amounts of irrigation water. All this excess water from seepage and irrigation has thrown a heavy load on the drainage capacity of these dry regions. The soluble salts of the soil have been taken up by the drainage water and carried down to lower levels. As irrigation has continued the drainage water has soon exceeded the moderate capacity of the soil. The ground water has risen, bringing up alkali salts in places, and water-logging the land in low spots.

The general remedy in the past, for such a condition, has been to line the main ditches and laterals with a concrete surfacing and install systems of tile drainage upon the land. Such treatment has been very effective, where the salts present in the soil were largely white alkali, that is, the sulfate and chloride of sodium. Where black alkali or sodium carbonate has been the principal salt it has been found extremely difficult to reclaim land which has reached a distinctly alkaline condition. In fact, up to the present time, there is no record of the complete reclamation of an area of black alkali land.

As a consequence of this difficulty, more interest is being taken in preventive drainage measures; that is, it has been found far safer to keep land from reaching a water-logged, alkaline condition, than to try and bring it back to productivity after it has been ruined by poor drainage. It may in fact be conservatively stated, that the present opinion of drainage engineers is that every irriga-

tion project should have provision made for drainage as well as for irrigation. This does not mean that all the land in the district will become water-logged, but certain areas in every district are sure to develop a high water table and need reclamation.

The latest development along this line is by the use of small pumping plants which keep the bottom water from rising above the lower levels of the soil. The success of this plan depends upon two things. The first essential is the occurrence of a permeable stratum which normally carries the percolating drainage water of the soil. Such a stratum may be located at a depth ranging anywhere from fifty to two hundred and fifty feet. If this natural drainage stratum is filled up and additional water is still added from higher levels, the water in the soil will actually be under pressure and will be continually forced upward toward the surface. This is believed to account for the phenomena sometimes observed in a tile drainage system, where water will stand close to the surface, even though a drain may be laid some ten or twenty feet away. In this instance, the water is rising from below faster than it can run into the drain by lateral flow. If the pressure is released on the lower stratum by penetrating this water-carrying layer, the drainage water has a chance to flow down in a normal manner.

The drainage wells are therefore driven down until they intercept a layer of sand, gravel or soft rock which will readily yield water to a pump. These wells commonly range in diameter, from twelve to twenty-four inches. The second essential of successful drainage is to install a pump of sufficient capacity to reduce the pressure in the water-containing stratum. This will re-establish the normal movement of water down through the soil and considerably reduce the water table in the area affected by the pump.

This method of drainage was first recommended in a report of the consulting board for the Salt River Valley Water Users' Association, issued in 1919. The board consisted of W. R. Elliott, D. W. Murphy and W. H. Code. Since that time, a series of pumps has been installed in the Salt River Valley, with very excellent results. A system of drainage pumps has also been installed in the Turlock Irrigation District and another in the Merced Irrigation District, both of which are located in the San Joaquin Valley, California.

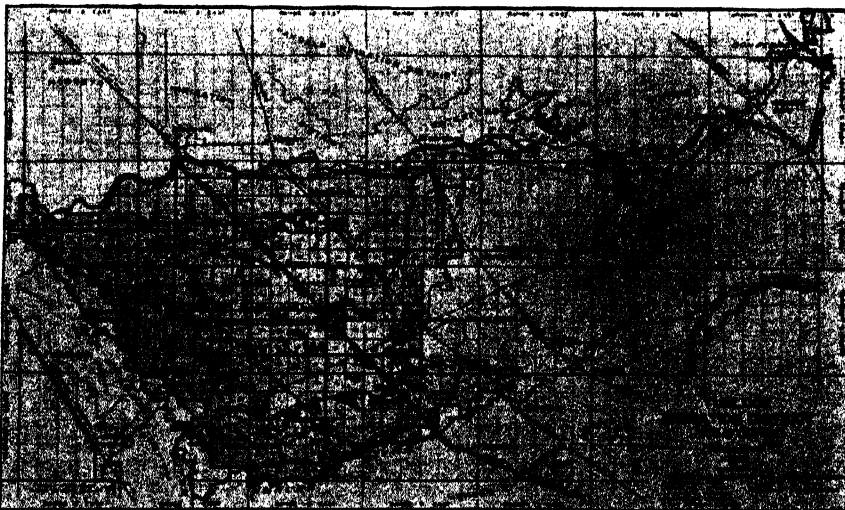


Plate I. Map of Turlock Irrigation District and location of drainage wells.

The writer recently visited the Turlock Irrigation District and examined a number of typical installations with R. V. Meikle, engineer for this district. The accompanying illustrations were furnished by courtesy of Professor Walter W. Weir, drainage engineer of the Division of Soil Technology, of the University of California.

The map of the Turlock Irrigation District, Plate I, shows the location of the first wells which were put down in this section. Additional wells are also located in and operated by the Delhi State Land Settlement. It was first believed that efficient drainage would call for a series of pumps regularly spaced throughout the entire irrigation district. A series of test wells was put down a mile apart over the 180,000 acres included in the Turlock District.

Readings were taken on these test wells throughout an irrigation season and it was found that the ground water had only risen in certain poorly-drained areas. About fifty bored wells were then put down, one to each swampy location, and fifteen horse-power, deep well turbine, electrically driven pumps were installed. The reduction of water level was extremely rapid, far more so than the results usually obtained with tile drainage systems. It only required a period of two to six weeks to materially lower the ground water in the poorly drained spots.

Plate II shows one of these poorly drained places in the Delhi Colony, before a drainage pump was installed. It will be seen that the water stood at a depth of one to two feet over a considerable area of land. Plate III shows the same poorly drained spot, six weeks later after a drainage pump was put in. The photograph was taken from exactly the same spot as Plate II. After reclamation these poorly drained areas have produced thoroughly satisfactory crops. Plate IV shows a field where a good crop of corn has just been harvested. The land shown here was another lake before a drainage pump was installed.

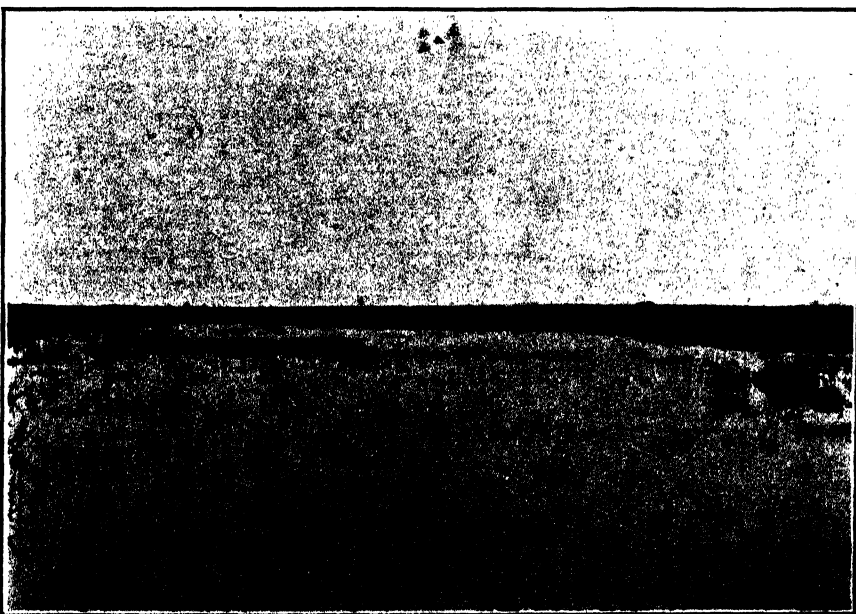


Plate II. Poorly drained area. Delhi Colony, before drainage.

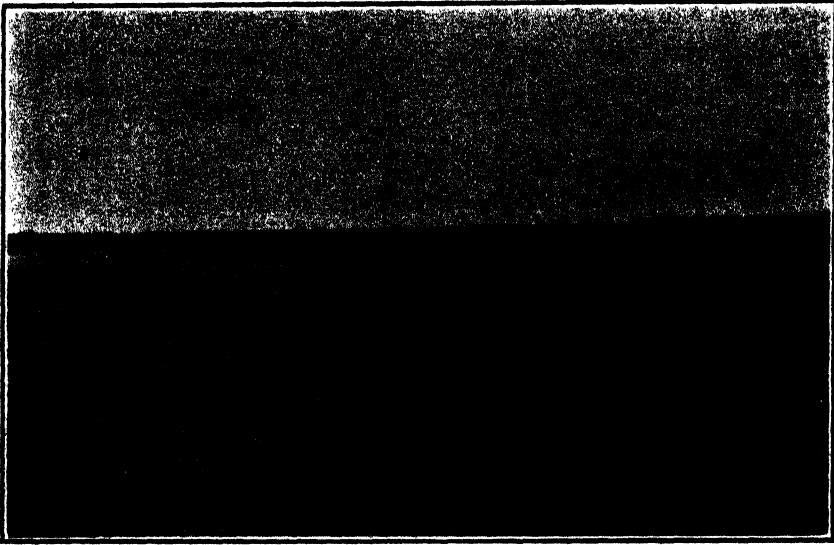


Plate III. Same area as Plate II, six weeks later, after drainage.

In the Turlock District the pumps at present installed are fifteen horse-power, which pump 750 to 1,200 gallons per minute. It has not been necessary to run all the plants absolutely continuously, so it is planned to put in 7.5- to 10-horse-power pumps in the new installations.

One great advantage that draining by pumping possesses over tile drainage system is that pumps can be put in upon low areas where it would be impossible to find a gravity outlet for tile. Several wells in the Turlock District deliver water at a higher elevation than the pump outlet. This is accomplished by pumping directly into a concrete pipe line which carries the water up to the desired discharge point. Excessive pressures on the concrete piping are avoided by putting in standpipes which give the necessary head, but avoid undue strain

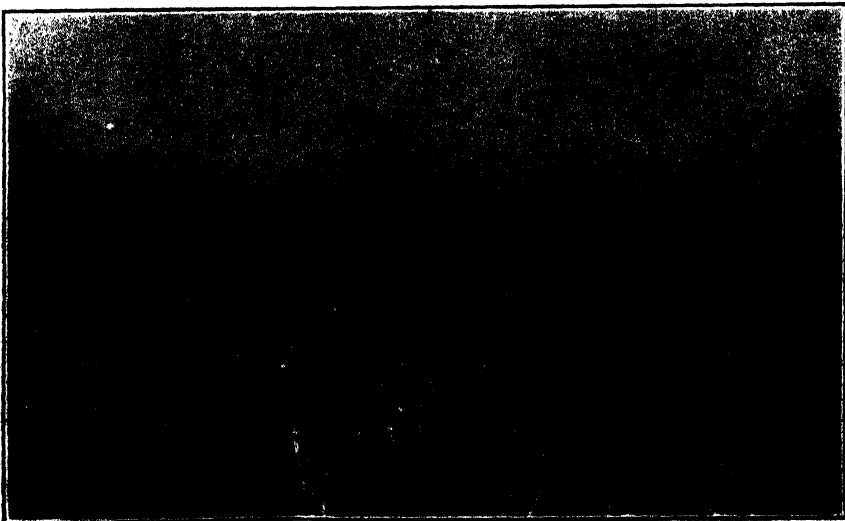


Plate IV. Field of corn just harvested. Formerly a lake until drained by pump.

on the line. Plate V illustrates such an installation in the Delhi Colony. The water is being delivered at a point some twenty feet higher than the pumps' discharge pipe.

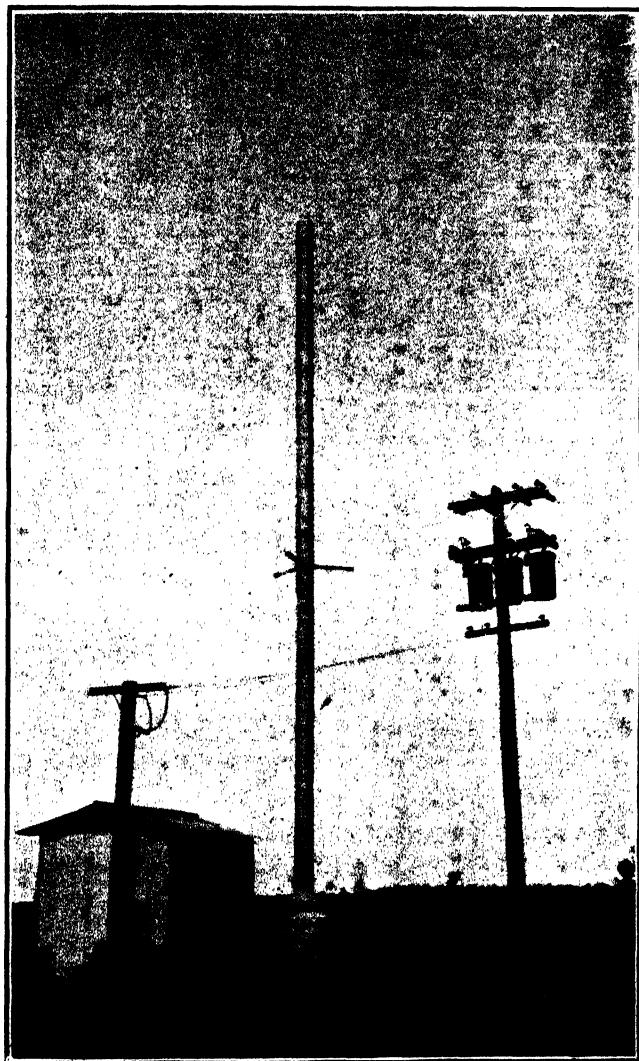


Plate V. Standpipe to give necessary head for delivery of water at higher elevation.

The use of pumps for drainage also points to a great advance in the economical use of water." It is inevitable that some excess irrigation water will pass down into the lower portion of the soil. If this can be pumped out wherever it shows a tendency to collect in the natural drainage stratum, additional land can be irrigated and the cost of drainage reclamation can be correspondingly reduced. All the water recovered by the California drainage pumping plants is sufficiently low in salts to be excellent water for irrigation. This is likely to be the case in most localities where the pumping is done from a saturated drainage stratum. Many of the drainage pumps are located so that they discharge directly into the regular irrigation canals. Plate VI shows such a pumping plant.

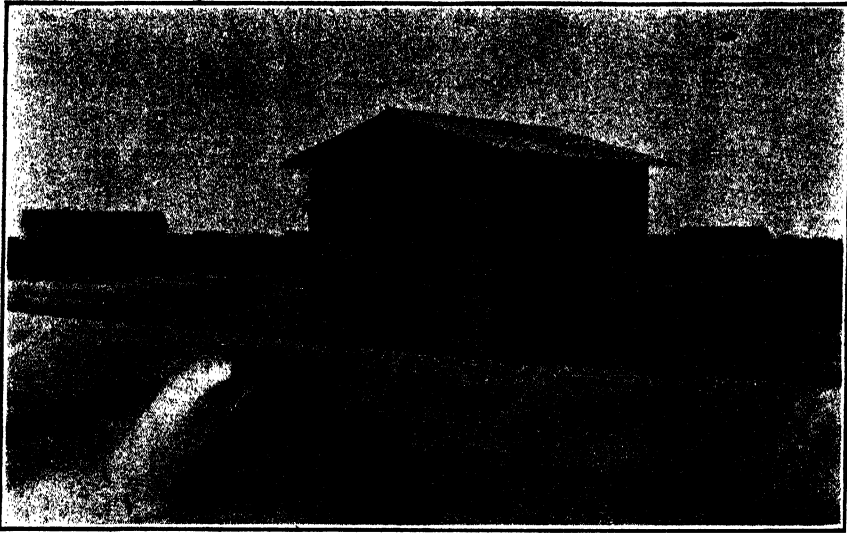


Plate VI. Drainage pump discharging directly into irrigation canal.

The depth of the drainage wells in the California projects has varied from 50 to 250 feet. The depth to which they have been driven is governed by the point at which a water-bearing stratum is encountered. In some projects it is considered necessary for a well to yield a minimum flow of 2 cubic feet per second, in order to justify pumping. The draw down of the pumps is usually located at 15 to 25 feet below the surface. If the pump keeps the water down to this point it means that the pressure on the lower water-bearing stratum is sufficiently reduced so that the surface water moves downward in a normal manner.

Work in the Turlock District has also been concentrated upon curtailing seepage losses from the main canals, and laterals, by lining these ditches. Plate VII shows the typical heavy concrete lining used on the main ditches of the district.

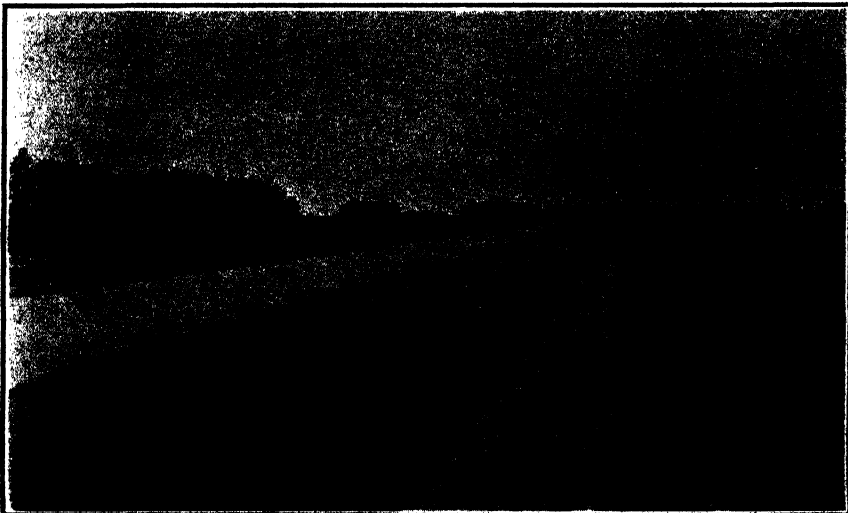


Plate VII. Heavy concrete lining of main ditches in Turlock Irrigation District.

The possibility of applying this system of drainage reclamation to Hawaiian conditions will depend upon several factors. It will be necessary to find water-bearing stratum, located at a moderate depth, which is likely to yield a good flow of water. It should be noted in this connection that the average island soil and subsoil is much more compact than are those of the semi-arid West. The movement of water is likely to be slower but if water-bearing strata are encountered, equally good results may possibly be obtained.

There are a number of sections on the irrigated plantations which would be materially benefited by drainage. This local need for drainage is frequently shown by an abnormally high water table during the entire rainy season. In dry weather as the water table recedes, there may be some local accumulations of salt, which occasionally reach the point where the per cent of salt injures cane growth. There is then a reduction of cane yield from the checking of growth by excess water in winter and some salt accumulation during the summer season. The success achieved by drainage reclamation through pumping, in the West, would warrant a consideration of its possible application in Hawaii. The first installations will, of course, be experimental and should only be made after a careful study of the local conditions.

Growing Sugar Cane in Water Cultures

By W. T. McGEORGE.

The use of water cultures in studying plant growth has found wide application as a means of noting the comparative effect of many organic and inorganic compounds upon plant roots. This method has been found to be especially adapted to investigating soil toxins or other inhibiting factors associated with retarded growth in the soils cropped to small grain crops. The ease with which these plants may be grown under such conditions is a point in favor and for this reason this method of studying soil fertility problems has been almost entirely limited to these plants. While we must recognize the limited value of water cultures, they furnish an excellent means of studying the conditions noted above. It has been demonstrated beyond question that roots in water cultures are more sensitive to toxic substances than when grown in soil. This must be considered in interpreting results.

In our studies of the factors associated with the poor root growth of sugar cane on certain of the island soils, some means of growing the plants under definitely controlled conditions in which it would be possible to observe the comparative root growth was imperative. Water cultures suggested a possible solution of this difficulty. In view of the wide variation in sugar cane (tassel) seed, as well as the short viability,* the possibility of seed appeared too doubtful. We then attempted to use the buds as follows:

* Notes on Seedling Work, Y. Kutsunai, Hawaiian Planters' Record, XXVII, p. 236.

In some of our experiments, the seed pieces were suspended in water to such a depth as to allow only the eye above the surface. In others, the seed pieces were planted in sand and soil and a limited germination of the roots and tops permitted before transferring to the water cultures. Only partial success attended these efforts. Fermentation of sugar in the seed stick promoted a heavy fungus growth which it was almost impossible to control. Germination of buds and roots

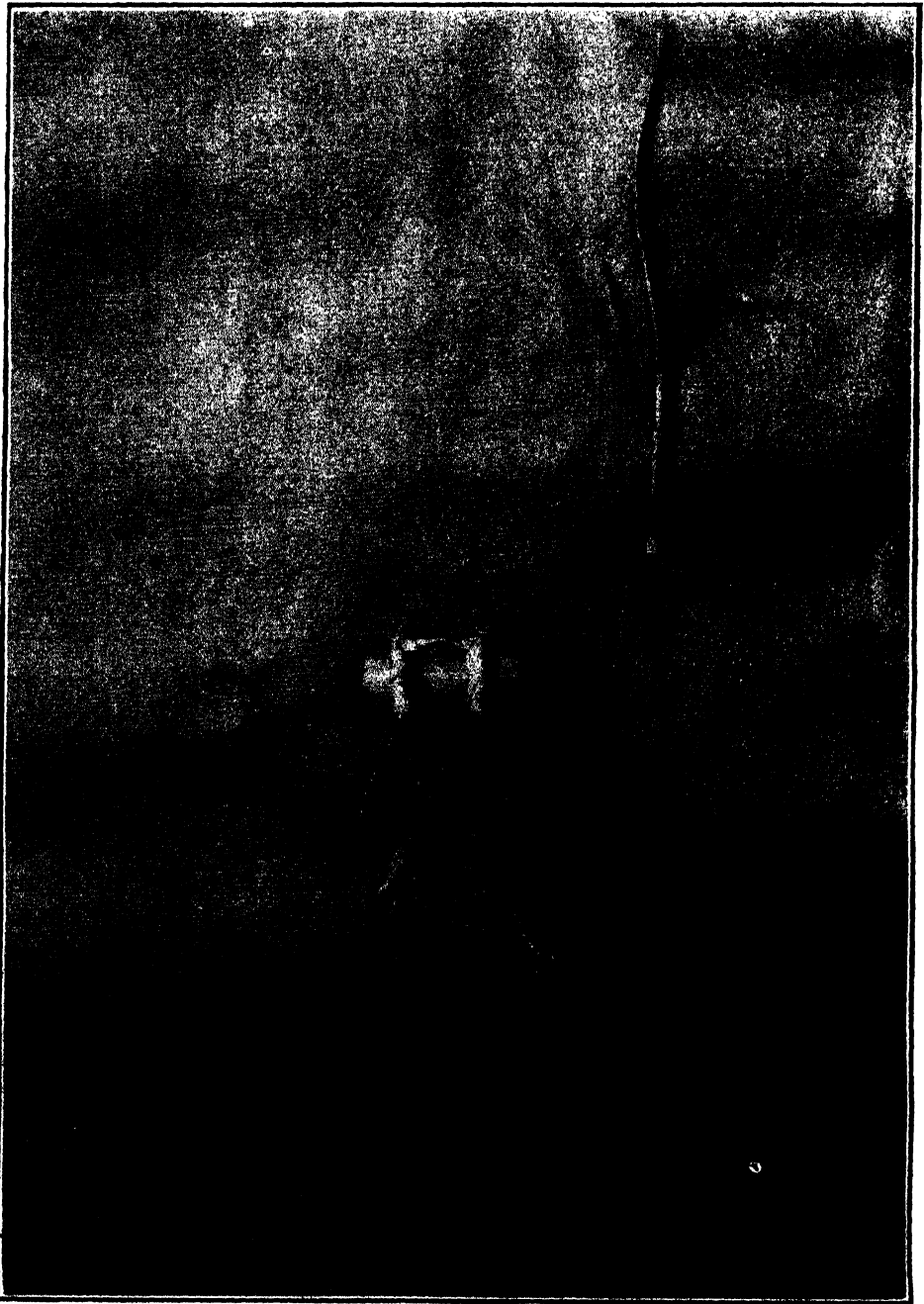


Fig. 1. Showing stage at which the shoot is removed from the seed-piece and suspended in water.

was satisfactory by this method; the difficulty lay with the maintenance of a clean culture during the period of growth. Sealing the ends of the stick with paraffin wax and sealing wax failed to correct this difficulty. It was necessary to change the culture solution almost daily in order to keep the culture medium free from fungus growth. Under such conditions, it is impossible to obtain reliable results. That is, whether to give primary or secondary importance to the influence of the fungi on the development of the plant.

In the asexual propagation of sugar cane we have two sets of roots developing. First, those issuing from the root band of the seed piece and later those issuing from the base of the stalk. The latter are more definitely associated with the nutrition of the plant. A determination of the possibility of working on the feeding roots was the next step and the question arose as to the possibility of forcing the early development of these roots. This would eliminate the seed piece entirely and its accompanying cultural difficulties. As a preliminary experiment, Lahaina and D 1135 seed pieces were planted in sand and the shoots allowed to grow to a height of 8 to 10 inches. At this height no feeding roots had appeared on the shoot. The plants were then removed from the sand culture and with a sharp knife the shoot was cut from the seed piece at its base (see

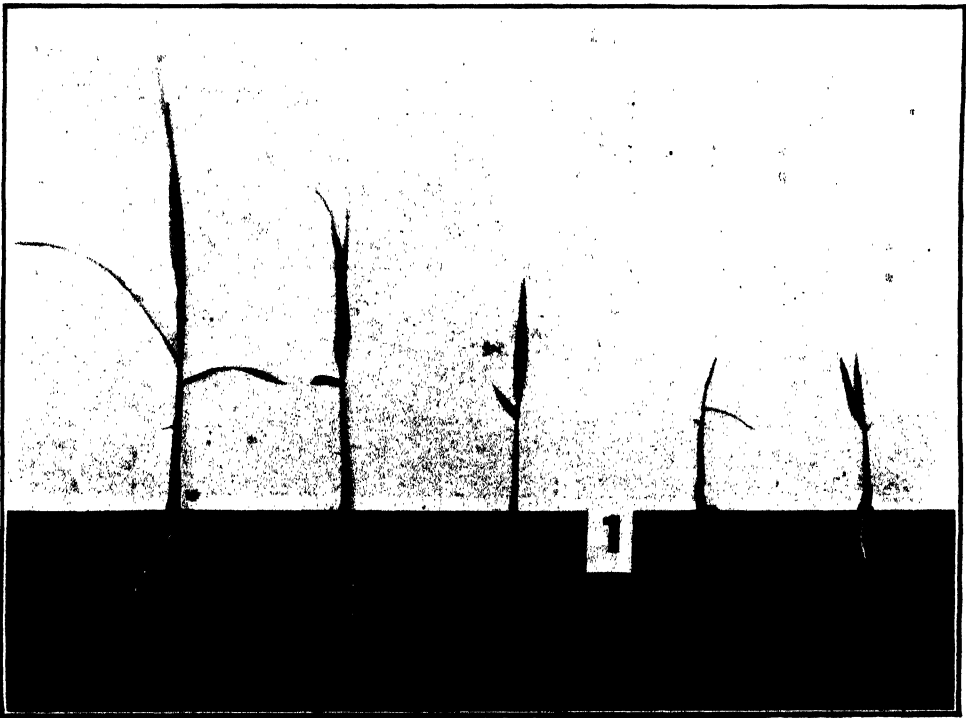


Fig. 2. D 1135 shoots grown in nutrient solution. Seed planted in soil box November 11. Shoots removed and placed in nutrient solution December 30. Height of shoots, left to right:

	Initial height	Final height
1	13.5 inches	25 inches
2	9.5 "	18 "
3	6 "	14 "
4	5.5 "	12 "
5	5.0 "	12 "

Date of photograph, Jan. 21, 1924.

Fig. 1). These shoots were then suspended in water with one-half inch of the base below the surface. This was effected by using a cork with a slot extending from one side to the center joining a hole to receive the plant. Roots appeared in four to six days time and made excellent growth thereafter. No difficulty was experienced with fungi and a clean culture solution was maintained with ease. X

This method was then tried on a number of different varieties of cane using shoots of varying heights. The results obtained are best illustrated by the following six illustrations.



Fig. 3. H 109 shoots grown in nutrient solution. Seed planted in soil box November 29. Shoots removed and placed in nutrient solution January 4, 1924. Height of shoots, left to right:

	Initial height	Final height
1	10 inches	32 inches
2	9 "	18 "
3	6 "	15 "

Date of photograph, Jan. 21, 1924. (Note the sturdy roots.)

In the preceding experiments due consideration must be given to the slow-growing period, namely, November and December. The plants were one month old before sufficient height of plant was obtained. During the summer months one week's time is ample. The results show that shoots only 5 inches long will develop roots by this method of culture but that best results will be obtained by using shoots approximately 10 inches in height.



Fig. 4. Yellow Caledonia shoots grown in nutrient solution. Seed planted in soil box November 29. Shoots removed and placed in nutrient solution, January 4, 1924. Height of shoots, left to right:

	Initial height	Final height
1	13 inches	29 inches
2	11 "	28 "
3	9 "	29 "

Date of photograph, Jan. 21, 1924.

It may be of interest to cite several practical applications of the above procedure. The low fertility of acid soils is now attributed in part to the presence of certain acid salts, namely those of iron, aluminum and manganese. In addition to the identification of these salts in our acid soils it is also necessary to determine their effect on the growth of sugar cane. We have carried out several hundred cultures, of which Figure 8 illustrates one set, yielding very definite results on this phase of the fertility problems associated with our acid soils.

In addition to the use of culture solutions prepared in the laboratory, the actual soil solution may also be used. To illustrate the following is of interest:

Our attention was called to an insert plot of Lahaina cane in a field of H 109. The former was very badly stunted while the latter was making good growth. The soil solution was separated from this soil (for method see Hawaiian Planters' Record, XXVI, p. 234) and used as a medium for growing Lahaina and H 109 shoots. Both varieties failed to send out roots. Shoots were then rooted in

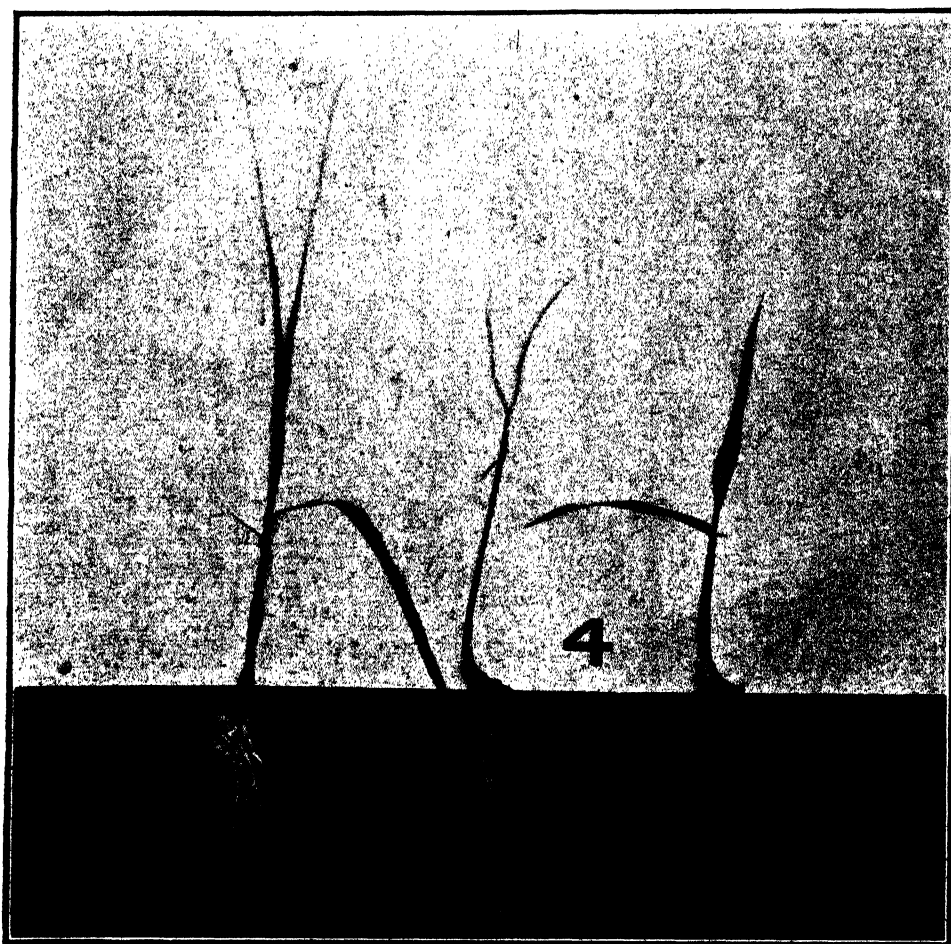


Fig. 5. Badila shoots grown in nutrient solution. Seed planted in soil box November 29. Shoots removed and placed in nutrient solution Dec. 22. Height of shoots, left to right:

	Initial height	Final height
1	14 inches	33 inches
2	8 "	18 "
3	6.5 "	18 "

Date of photograph, Jan. 21, 1924.

tap water before suspending in the soil solution. Two days after placing in the solution the Lahaina plant was plainly in distress and continued to die rapidly from this time. The H 109 showed very little evidence of toxicity beyond a faint stubby appearance on the root hairs. The analysis of the soil solution showed an extremely high concentration of salts on the basis of which a series of culture solutions was prepared and a greater resistance to salt in the H 109 variety was thereby proven.

An additional application of this method is illustrated in Figure 9. This figure is self explanatory and shows the comparative growth of D 1135 and Yellow Caledonia in the soil solution from a field on which Pahala blight is prevalent and also from a field which is free from blight.

X

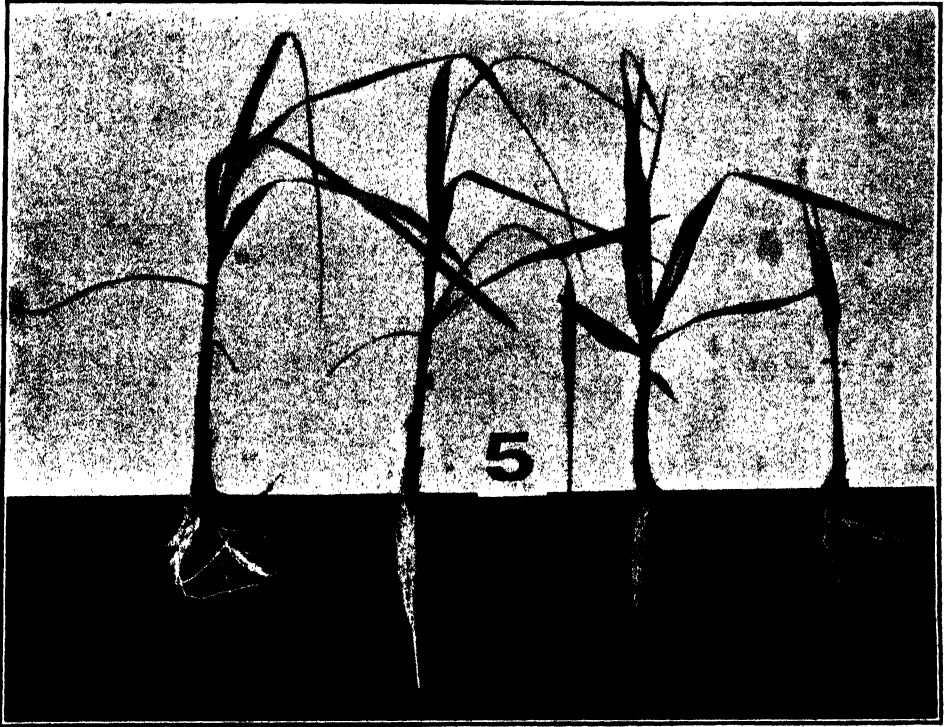


Fig. 6. Lahaina shoots grown in nutrient solution. Seed planted in soil box November 29. Shoots removed and placed in nutrient solution December 30. Height of shoots, left to right:

	Initial height	Final height
1	17 inches	45 inches
2	10.5 "	29 "
3	8.5 "	33 "
4	5.5 "	23 "

Date of photograph, Jan. 21, 1924.

It is suggested from the results obtained to date in the application of water cultures to the study of the fertility of sugar cane soils that such a procedure will lend valuable data to the solution of our problems. While heretofore this method has been applied principally to the small grain crops it may be applied with equal ease and value to sugar cane.

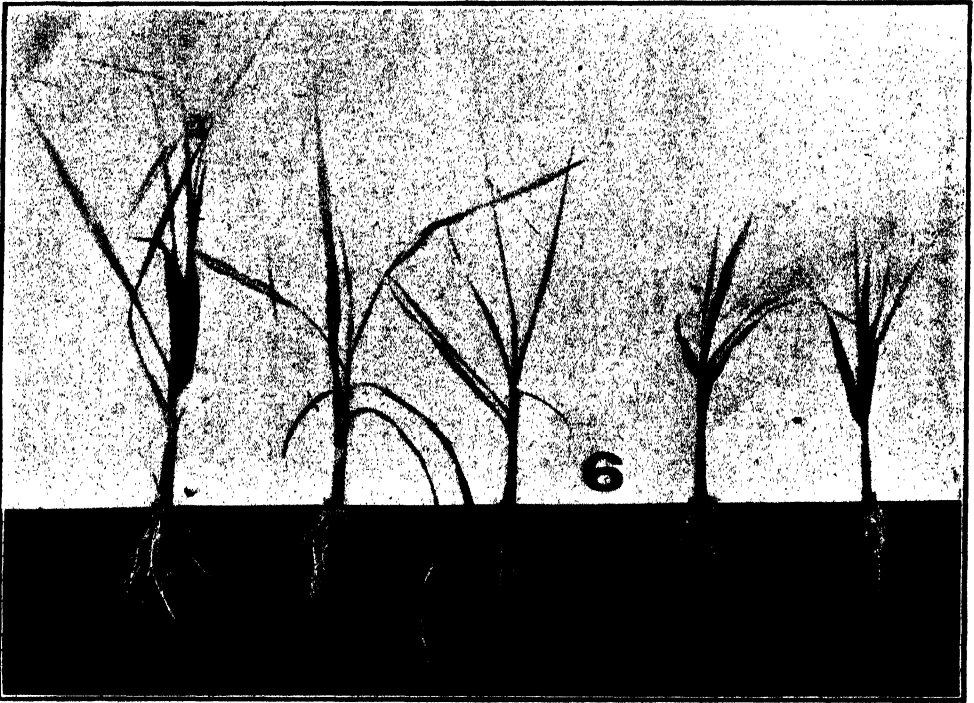


Fig. 7. Uba shoots grown in nutrient solution. Seed planted in soil November 29. Shoots removed and placed in water cultures December 22. Height of shoots, left to right:

	Initial height	Final height
1	11 inches	34 inches
2	16 "	30 "
3	12.5 "	27 "
4	10 "	24 "
5	6 "	22 "

Date of photograph, Jan. 21, 1924. All shoots had stooled.



Fig. 8. Showing method of growing cane shoots in water cultures. On the left, plants growing in a nutrient solution. On the right, plants growing in the presence of toxic amounts of aluminum chloride. This figure illustrates the value of this method in studying the effect of toxic substances on cane growth. Plants one month old.

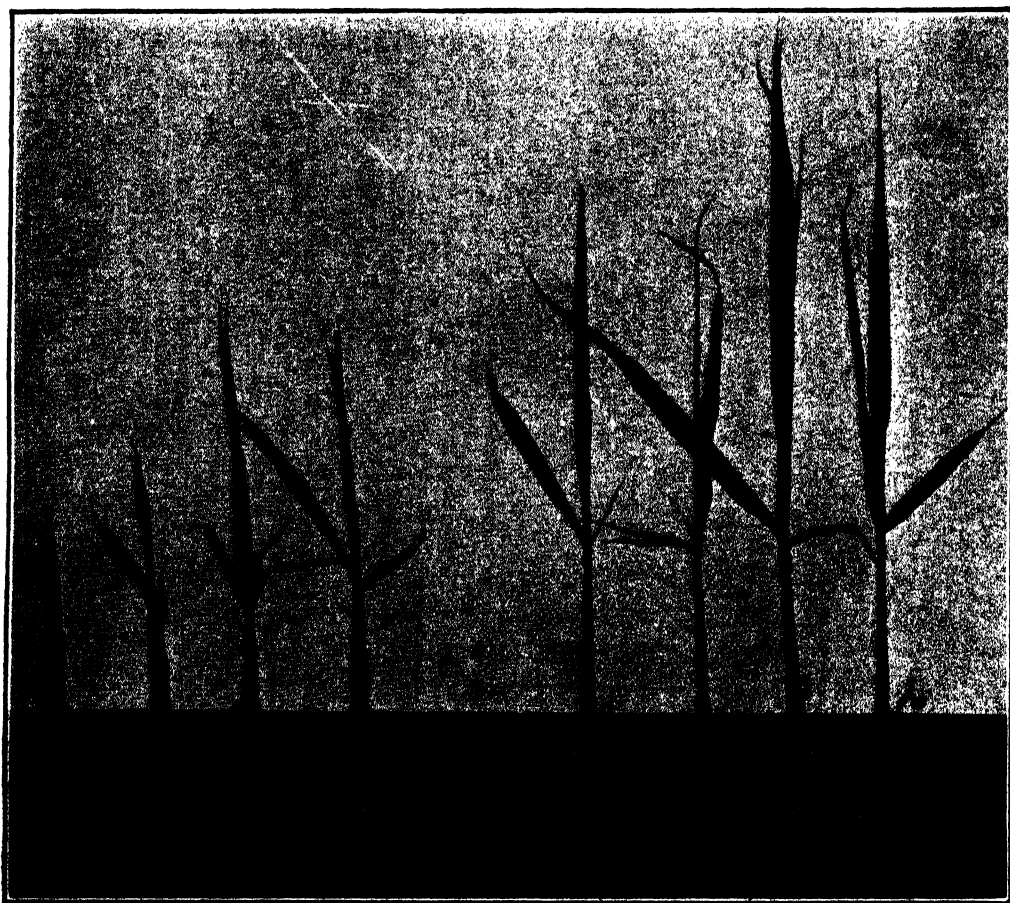


Fig. 9. Showing growth of cane shoot, two-week period, in soil solution. Reading from left to right:

- 1—Yellow Caledonia, soil solution from Lower Goodale. Bad blight.
- 2—Yellow Caledonia, subsoil solution from Lower Goodale. Bad blight.
- 3—Yellow Caledonia, soil solution from Wood Valley. Trace of blight.
- 4—Yellow Caledonia, soil solution from Mud flow. Free from blight.
- 5—D 1135, soil solution from Lower Goodale.
- 6—D 1135, subsoil solution from Lower Goodale.
- 7—D 1135, soil solution from Wood Valley.
- 8—D 1135, soil solution from Mud flow.

Salt Accumulation in Oahu Soils—Its Relation to Poor Growth of Lahaina*

By W. T. McGEORGE.

In outlining a plan of study to cover an investigation of the soil types on which sugar cane root-rot is or has been prevalent, it was evident that wide variations were involved. We had previously shown the acidity of Hawaiian soils to be in part a result of the presence of soluble salts of iron, aluminum and manganese. In the Eastern and Central States it has been definitely proven that there is an association between the presence of the salts of these elements and corn root-rot. The first phase of our investigation has, on the basis of the above, involved a determination of the toxicity of these salts toward sugar cane roots and further definite information as to their presence in our soils. That is, whether or not we might expect to find them present in all soil types. While we have strong indications that plants obtain, to a certain extent, mineral matter from compounds of low solubility, we usually associate the greater toxicity with the more soluble substances.

Our work has thus far shown a definite toxic action of aluminum salts toward sugar cane roots with the least resistance in Lahaina. In searching for the soluble salts of these elements in our soils a series of soils varying in reaction from pH 4.2 to 8.0 was selected. A careful study of this series indicated that these salts were present in the soil solution only in the soils of pH 5.8 (this point not absolute but very close) or less. This in spite of the fact that all soils falling between 5.8 and 7.0 are acid. On applying the above data to island types we find

* In submitting this article for publication Mr. McGeorge wrote as follows:

“Attached herewith I submit a preliminary report on that phase of our soil investigations covering root-rot on the alkaline and faintly acid soils on Oahu. These soils, we find, contain no acid salts of aluminum.

“The evidence strongly indicates the high salt concentration to be involved. By salt I refer not to sodium chloride alone but include the salts of calcium and magnesium which are present in comparatively high concentration in the soil solution. The toxicity of sodium chloride has been suggested by Maxwell, Eckart and others. The effect of the chlorides of calcium and magnesium is a comparatively unexplored field.

“I am submitting this report in a form suitable for publishing in the Record, should you care to do so.

“On the basis of the above, I think we should plan a very complete study, in water cultures, of the effect of the chlorides and sulphates of calcium, magnesium and sodium upon sugar cane and the relative resistance of different varieties where toxicity is shown. The effect of high salt concentration upon osmotic absorption by the cane roots is another phase that should be studied. In view of observed appearance of the cane leaves, as of a lack of water, we may find some interesting comparisons of the relative osmotic absorption of Lahaina and other varieties which would be of considerable value.

“I also believe that a drainage experiment with Lahaina plantings on one or more of these high salt areas would be of considerable value in determining the association of this factor with ‘Lahaina Disease’.”

many of the mauka fields on Kauai as well as the Hamakua coast, Hilo and Olaa districts fall in this class. It is very evident therefore, that we must search for other factors as a cause of low root vitality in the slightly acid, neutral and alkaline types. The latter classes include practically all the lower fields of the Oahu plantations.

We were fortunate at this time in having available a small plot of Lahaina cane planted by Dr. Lyon for experimental purposes in a field of H 109. The Lahaina was plainly in great distress while the H 109 appeared to be making normal growth. We therefore obtained several hundred pounds of the soil for the purpose of removing the soil solution or soil water* for analysis and use as a culture medium for growing cane shoots.

In studying the growth of sugar cane in water cultures we have obtained best results by starting the seed sticks in sand or soil and growing therein to a height of 8" to 15". The shoot is then cut off the seed piece and suspended in water. In this manner shoots of Lahaina and H 109 were prepared and suspended in the soil solution from this soil. All plants except the checks which were grown in a nutrient solution died very rapidly, the Lahaina much more rapidly than the H 109. No roots had developed on the shoots of either variety. This experiment was then repeated as follows: New shoots of both the above varieties were grown in properly balanced nutrient solutions until well supplied with feeding roots and then transferred to the soil solution. Two days later, the Lahaina shoots were plainly in distress starting with a drying of the leaf tips and died rapidly from this point. The H 109 showed very little evidence of toxicity beyond a slight stubby appearance of the root hairs. These cultural experiments plainly show the greater resistance of H 109 to the conditions existant in this field and the presence of the toxic bodies in the soil solution.

The analysis of the soil solution showed the presence of 15,710 parts per million solids of which 11,090 was composed of non-volatile or inorganic compounds. It may be of interest to compare this figure with other results obtained on local soils which indicate 1,000 parts per million to be very high. The salts present in this soil were composed almost entirely of the chlorides and sulphates of calcium, magnesium and sodium. The results strongly indicate that this high salt concentration in the soil solution was the inhibiting factor. With this in mind, samples of soil were obtained from a number of areas on the island of Oahu, where Lahaina failed, where it is now making poor growth and, where it is still growing normally. The soil solution was removed from each by the displacement method and analysed. The results are given in Table I.

DESCRIPTION OF SAMPLES.

Soils 1 and 2. These samples are taken from an experimental plot of Lahaina cane where the cane is very badly stunted. H 109, the crop cane, other than a slight drying of the leaf tips, shows a normal growth. The field is low-lying, poorly drained and the soil a heavy clay, very sticky from salt accumulation. Sample No. 1 was taken in November before the rains had commenced, the cane

* For description of method see *Hawaiian Planters' Record*, XVI, p. 234.



Showing field of Lahaina and H 109 in a field of high salt concentration. Small plants in foreground are Lahaina, H 109 in background. Soil No. 1, Table 1.



Showing field of Lahaina and H 109 in a field of high salt concentration. Plants on right are Lahaina. H 109 on left. Soil No. 3, Table 1.

was only a few months old and the soil exposed to high evaporation during the entire summer. These factors would tend to promote maximum accumulation of dissolved salts by surface evaporation. Sample No. 2 was taken from this plot in February after several months of rain and during which time there occurred two heavy rainfalls.



Showing field of Lahaina and H 109 in a field of high salt concentration. Small plants in foreground, Lahaina. H 109 in background. Soil No. 1, Table 1.

TABLE I.

Soil Solution—Composition.

Results Expressed in Parts per Million Soil Solution.

	Date	Soil	Per Cent	Total	Non Vol.	Chlorine	Lime	Sulphur	Magnesia	Soda	Potash
	Sampled	No.	H ₂ O in Soil	Solids	Solids	Cl	CaO	Trioxide	MgO	Na ₂ O	K ₂ O
Ewa Field 14	November, 1923.....	1	14	15,710	11,090	6,664	3,118	1,036	1,336	2,179	202
Ewa Field 14.....	February, 1924.....	2	18	2,934	2,238	1,084	....	....	....	....	...
Ewa Field 1 D.....	December 19, 1923..	3	22	4,558	2,548	1,239	156	82	142	918	138
Ewa Field 1 D.....	January 25, 1924....	4	22	1,202	716	227	112	104	95	208	72
Ewa Field 1 D.....	December 19, 1923..	5	22	3,278	1,988	1,186	760	304	720	....	121
Ewa Field 1 D.....	January 25, 1924....	6	22	1,120	776	362	101	72	99	230	42
Waipio—Office	December 19, 1923..	7	20	3,764	2,766	1,584	359	198	279	961	...
Waipio Exp. T.....	January 25, 1924....	8	18	660	472	138	53	74	42	192	24
Waialua Gay 1.....	February 1, 1924....	9	15	1,684	986	371	179	83	81	248	66
Waialua Gay 1.....	February 7, 1924....	10	26	1,112	708	308	....	....	....	....	...
Oahu Field 32 A.....	February 24, 1924... 11	18	732	532	231	....	....	....	....	....	...
Oahu Field 33 A.....	February 24, 1924... 12	26	962	744	259	....	....	....	....	....	...
Oahu Field 34 A.....	February 24, 1924... 13	24	1,914	1,582	819	....	....	....	....	....	...
Waialua Ranch 7.....	February 7, 1924.... 14	24	548	398	53	45	63	44	160	48	
Waialua Ranch 4.....	February 7, 1924.... 15	20	514	312	118	45	36	31	162	57	
Oahu—Kipapa	January 25, 1924.... 16	20	980	594	99	106	122	66	168	24	
Oahu Field 12.....	January 25, 1924.... 17	21	398	240	85	39	28	25	68	52	

Soils 3, 4, 5 and 6. These samples were taken from an experimental area of Lahaina cane located at a slightly higher altitude. The cane was making much better growth in this experiment. Some plots were in fact very good. It is significant that cane growing on soil No. 3 was considerably more stunted than that on soil No. 5. The reduction in salt concentration resulting from the rains is apparent in a comparison of Samples 3 and 5 with 4 and 6.

Soils 7 and 8. These samples were taken at the Waipio substation. Sample No. 7 was taken, before rains began, from a field in which Lahaina had failed. Sample No. 8 was taken from a spot where Lahaina was making pretty fair growth but had previously failed. These samples were taken from different fields and several heavy rains had occurred in the interim.

Soils 9 and 10. These samples were taken from a field at Waialua, planted to Lahaina and Caledonia. Our attention was called to this field in February so that we have no comparison to make with salt concentration previous to the rainy season. The Lahaina cane was badly stunted at this time while Yellow Caledonia appeared to be making good growth. The area is a low-lying field, poorly drained and possesses the sticky texture characteristic of high salt concentration in the soil moisture.



Showing field of Lahaina and Yellow Caledonia in a field of high salt concentration. Small plants Lahaina, and large plants Yellow Caledonia.

Soils 11, 12 and 13. These samples were taken from the peninsular fields of Oahu Sugar Company where Lahaina first failed on this island.

Soils 14 and 15. These samples were taken in mauka fields at Waialua, mauka of soils 9 and 10. Lahaina cane was making good growth in both soils. The fields are located on gently sloping land, well drained.

Soils 16 and 17. These samples were taken from fields at Oahu Plantation where Lahaina was making normal growth.

DISCUSSION.

It is interesting to note, in this connection, the observations made in previous investigations and by plantation men which are on file or published in the Hawaiian Planters' Record.

In October, 1905, Mr. Lewton-Brain made the following notation: "Plants have very feeble hold on the soil. The root fungus mycelium is abundant about the stump and roots. But did not find the mycelium in the soil even quite close to the stump. A few weeks later with constant large irrigation the canes apparently entirely recover. In some cases plants are too far gone to recover." Cobb commenting on the above suggests the fungus must have been put in with the seed.

In a report dated October 21, 1908, Dr. Lyon suggests from observations at Ewa that the appearance of the Lahaina is not that of an infectious fungus disease but rather of poor drainage.

A report by Larsen dated February 5, 1909, after an examination of Ewa fields, gives the following significant points:

1. The cane was dwarfed accompanied by *dry leaf tips*.
2. The injury occurred mainly along the irrigation ditches. The most severely affected patches occurred near the main ditches that are constantly full of water.
3. The stellate crystal fungus was present on the roots of affected plants but was *not* abundant enough to account for the injury. It had evidently come on as a *secondary* trouble.
4. The deeper roots were usually dead while those near the surface were often healthy. The deeper dead roots were *quite free* from fungi of any sort.

He also calls attention to the lateral capillarity or seepage through the soil from the ditches and suggests the water-logged condition as a factor. Nine months later he again made observations at Ewa and noted the disease in well drained fields from which he suggests the influence of some other factor besides drainage.

In November, 1909, Dr. Lyon noted the sound condition of the seed in Ewa fields and describes the condition of the cane as of that suffering for water. He suggests that the condition of the cane is not due to fungi or nematodes, but more probably to poor drainage permitting the accumulation of undesirable salts in the soil. One year later he again observed the diseased fields with the same notations.

In October, 1911, Dr. Lyon reports growing healthy stools from seed of diseased cane and on transferring diseased stools to good soil, they developed into vigorous plants.

In a report of April 27, 1912, Mr. Eckart mentions the excellent results obtained by Mr. E. K. Bull, Oahu, by hilling up and planting in the row rather than furrow.

In 1910, Mr. Peck carried on extensive chemical and biological studies on Oahu diseased soils with little or no indication of inhibiting factors other than the deflocculated physical state. He suggested the presence of bicarbonates.

In the Annual Report for 1913, Mr. Peck mentions having found high alkalinity in some of the diseased soils.

In 1915, Mr. Agee* gave a general summary of the soil work to date on experiments with diseased fields. The following soil treatments were tried: Gypsum with and without ammonium sulphate, lime as oxide and carbonate, reverted phosphate, stable manure, extra fertilization and irrigation, cyanide, carbon black, pyrogalllic acid and carbon bisulphide. No favorable results were obtained from any of the above. On the other hand, mixing 80 per cent virgin and 20 per cent affected soil gave good results in tub experiments.

Green manuring gave some response on plant cane (legumes were not irrigated).

Larsen† reports two experiments, in one of which legumes were grown one year and another only four months. In the latter experiment the cane was badly diseased.

In 1915, Speare made an extended survey of the fields of Oahu and Honolulu Plantations. The following observations are significant:

Oahu Plantation. Both mauka and makai fields affected. Almost invariably the disease is more intense and first appears in connection with watercourses, level ditches and straight ditches. If in connection with a level ditch, the cane appears in bad condition below it and good above. It will thus run along the makai side of the ditch for some distance and then after a time appear on the mauka side after which it spreads more rapidly. Similarly it seems to appear along both sides of the watercourses first. He says the cause is augmented by pump water.

Honolulu Plantation. The disease was worse in the high coral fields around Puuloa. "One striking exception is apparent in Field 17 where an area one watercourse wide is in good cane though surrounded by diseased cane. This small area receives 'night water' from the mill in distinction from the neighboring areas."

Burgess studied the problem, dealing very thoroughly with the association of black alkali which had previously been suggested by both Peck and Eckart. He found on many diseased areas a greater alkali concentration. Some significant observations are of interest. * "The worst plants are always to be found along water ditches or in little sinks or basins." "It is commonly recognized that the condition of the Lahaina cane is much better this year (1917) in many fields on Oahu that have suffered from a diseased condition for the past several seasons." "It is important to note that the rainfall for the past two winters has been exceedingly heavy." On analysis he found less black and white alkali in the soils in 1917 than was present in 1915.

* Hawaiian Planters' Record, XII, p. 374.

† Hawaiian Planters' Record, XV, p. 70.

In March, 1919, the late Mr. G. F. Renton stated, "In any dry year following a dry winter Lahaina disease spreads more rapidly than in an ordinary wet year following a wet winter."

There is abundant evidence in the preceding observations that salt accumulation in our lower irrigated fields may have been involved in the lowering vitality of Lahaina on our neutral and alkaline soils. This evidence is available both in the physiological observations upon the conditions of the plants such as dry leaf tips and indications of lack of water and in the notations of soil conditions. In the latter, may be included contiguous irrigation ditches and less appearance of the disease during years of heavy rainfall.

Both Maxwell and Eckart called attention to the toxic action of sodium chloride toward sugar cane.

We have shown by cultural experiments using the soil solution from soil No. 1 that this high salt concentration is toxic toward Lahaina while less so for H 109. Also we have shown in a preliminary experiment by making up culture solutions of known sodium chloride content that H 109 is much more resistant to high concentrations of this salt than Lahaina. There are present, however, chlorides of calcium and magnesium as well as the sulphates which are notably higher in the poor areas. Our study of the toxicity of aluminum and manganese salts in acid soils has shown in water cultures a notably greater toxic action from the chlorides. The question arises as to the effects of chlorides of calcium and magnesium.

Comparatively little has been done on the pathological effect of an excess of salts (not NaCl alone) upon sugar cane. Also of the effect of an excess or a deficiency of essential and non-essential salts upon their absorption or assimilation by the cane plant. Also we know little or nothing of the degree of selection which the different cane varieties exercise in their absorption of essential and non-essential elements. Evidence strongly indicates such a variation to be inherent in sugar cane.

The effect of high salt concentration itself, that is, its physical not physiological influence, is also little understood. The semi-permeable membrane which separates the root cell sap from the soil solution plays a very important role in absorption. It is evident therefore, that where we have a higher concentration in the soil solution than in the cell sap of the roots equilibrium tendencies will work against the absorption of water by the plant. In other words the plant will suffer for water. Antagonistic action of the elements present in the soil solution adds further to the complexities. The problem therefore, involves practically an unexplored field. Hence, while there is very strong proof in the data in Table 1, as well as the numerous observations, that salt accumulation has been involved in the low vitality of Lahaina, no simple explanation will suffice. There is a wide degree of variation in the salt concentration of the soil solution influenced principally by seasonal factors. The comparative figures in Table 1 show the marked effect of a few months of the rainy season on salt concentration. This concentration is greatest during the summer months at which time its effect upon the plant vitality is also at a maximum. The crop therefore, enters the slow-growing winter months with a reduced vitality. We must, in addition, recognize

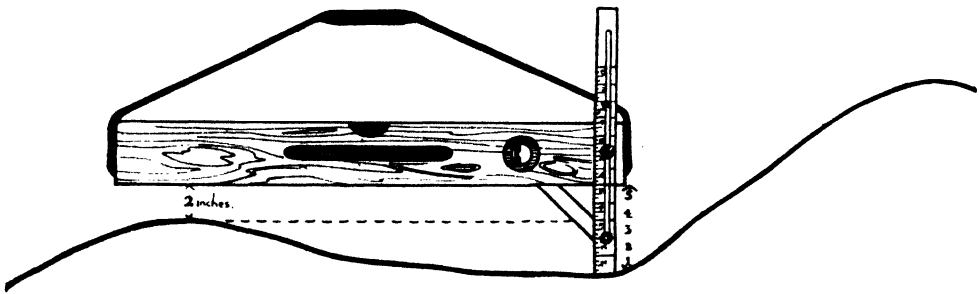
the possible injury to the root cells which will follow rapid changes in the salt concentration as this would be accompanied by wide osmotic pressure variations.

We are planning, on the basis of the above, a detailed study of the effect of the concentration and variable proportions of the sulphates and chlorides of calcium, magnesium and sodium on sugar cane which we anticipate will clear up many doubtful points regarding the role of salt accumulation in the degree of plant vitality.

The Steffee Line Gauge

Any development offers interest if it tends to add precision to sugar cane agriculture.

On steep hillsides or pali the eye is very deceptive in remarking the lines to hold irrigation water. A simple and useful device has been designed by J. B. Steffee, of the Ewa Plantation Company, to be used in this connection. He gives the following description of it:



A new line gauge has been found to be of considerable value in pulling up lines on sloping fields. It consists of an ordinary 30-inch carpenter's level with attachments of a sliding brass ferrule, graduated, and a handle for convenience. The ferrule indicates the desired depth of water in the line and the level shows how much soil should be added to the bank in order to hold the water.

It has always been the practise to have laborers work over the field, after a crop is harvested, pulling up lines without any standard to go by. A recent test with the gauge showed that these banks vary a great deal in water-holding capacity. Some lines held as little as $2\frac{1}{4}$ inches while others could easily contain 8 inches. A $2\frac{1}{4}$ -inch irrigation will obviously fall far short of producing good growth results, especially during hot months and on porous soil. On the other hand, a bank holding an 8-inch irrigation is larger than is necessary and a part of the labor in making it has been wasted.

On level fields sufficiently good lines can be built up to produce good results judging with the eye without mechanical assistance, but curving lines on sloping land are frequently deceptive.

The use of the gauge will tend to standardize lines on pali fields and it is believed will work to advantage in three ways, viz:

1. Increase tonnage by insuring a sufficient uniform irrigation.
2. Eliminate unnecessary labor in pulling up too much soil for bank.
3. Tend to have a good moral effect on workers who will know that the device is going to be applied to their work and will show deficiencies.

[H. P. A.]

Soil Analysis—Its Limitations and Possibilities*

By W. T. McGEORGE.

In studying the fertilizer requirements of crops and soils, soil analysis has steadily lost in favor. There are, among students of soil fertility, few remaining who place any value whatever upon the ordinary methods. *During the early part of the last century, von Liebig, a German agricultural chemist, discovered that plants required a certain amount of mineral salts, the supplying of which necessarily lay through the medium of the soil solution. *It was only a natural consequence of this discovery that attempts should be made to ascertain the fertilizer needs of the crop by a chemical analysis. *The digestion of soils by strong acids constituted the initial attempts but it was later noted that there existed a wide variation in solubility or availability of the mineral nutrients. Thence followed attempts to measure the available mineral soil constituents and to distinguish between these forms and those not readily available for assimilation by the plant. A tangle of empirical methods was finally reached with a bewildering array of solvents and methods of extraction constituting the only results of many years' effort. *Foremost among those of the old school who attached considerable value to the use of strong acid digestion was Hilgard, who considered this method a measure of the "Zeolitic" reserve. If the analysis fell below a certain percentage of any important plant food constituent it was considered deficient and application as fertilizer was recommended. In another school may be included the English chemist, Dyer, and others whose attempts to distinguish between the available and non-available mineral constituents were based on the theory that all plant roots secreted acids which aided in the solution of soil minerals. This latter theory exploded with the discovery that there was no indication that growing roots secreted any acid other than carbonic. *

We might safely conclude that few attempts to associate soil analysis with soil fertility have succeeded definitely. The most notable recognition of this we find in the last "Methods of Analysis" of the Association of Official Agricultural Chemists in which the old official method has been withdrawn.

The fallacious teachings of the old school have penetrated deeply our agrarian population. A soil analysis appears as a simple and logical procedure to the practical tiller of the soil and few there are who would not readily associate with it a valuable significance in soil management. *Few stop to realize that the amounts of plant food added as fertilizer are far beyond the range of accuracy of most methods of soil analysis; that the amounts required to stimulate plant growth are many times less than that already present in the soil. Modern experimental tendencies, therefore, are now being directed toward a more complete knowledge of the inherent physiological properties of plants as influenced by season, plant food balance and other factors. *

* Originally published in *The Louisiana Planter*.

There are few soils but what contain enough mineral plant food to supply the immediate crop needs if it were available, although in establishing a permanent program it is of no small value to know the reserve and make some attempts to retain this. What is most important to recognize is our knowledge that all plants draw most heavily upon the plant food supply at certain definite seasons. Therefore, the most essential knowledge required is the degree of availability and when such is deficient to make fertilizer applications for the vital growing period.

In view of the generally recognized failure of soil analysis in diversified agriculture the question arises as to its value in a more intensive single cropping system such as is found in the sugar industry. ✕ In Hawaii, where the soils are under a continual drain, where rotation is rarely practiced, and the fields are cropped continuously it is essential to either ascertain the reserve supply or maintain this through a knowledge of the plant food removed. Marked deficiencies or abundance are usually indicated by a determination of the total soil constituents and this method therefore has some value in formulating a permanent program. That is, where fertilization shows that availability is low, attempts should be made to increase this availability by cultural methods. For this reason it is often of value to determine this reserve supply, although the data thus obtained are of no immediate value. ✓

In attempting to determine by chemical methods the availability of soil minerals we are confronted with a more and extremely complex problem. The possible combinations in the soil are legion and in order to detect the change in soil composition which results from fertilization, which amounts are sufficient to stimulate plant growth, it is necessary to resort to methods accurate to the third or possible fourth decimal place of percentages.

Heavy fertilization on the sugar lands of Hawaii is a necessity in maintaining the high yields necessary to offset the lower cost of production in most other cane growing countries. It is therefore imperative to utilize every possible means of aiding the formulation of fertilizer practices. The question therefore arises, what is the limit to the value that can be placed upon methods of determining plant food availability?

We are limited in this to the use of water and dilute mineral or organic acids. In Hawaiian soils the high colloidal content of which imparts strong fixing powers, little success has attended the use of water extracts or analyses of the soil solution. This applies especially to phosphates. We find sugar cane makes heavy demands upon the mineral nutrients at certain definite stages of growth. It is therefore evident that a water extract or the separation of the soil solution which is too greatly influenced by the fixing power of the soil will be of little value. With our crop, adequate supplies of available plant food or the rate at which the replenishment of the soil solution is possible is the important factor rather than a determination of the actual concentration of the soil solution. Dilute acids, therefore, appear to be our only recourse. A low reserve is rarely noted in Hawaiian soils, it is mainly a question of availability.

It must be admitted at the outset that any sound theoretical principle on which to base the relation of the solvent power of any acid to the availability of any plant food constituent is entirely lacking. ✓ It is true that the solvent properties

of dilute acids under definite conditions for any phosphate or potash compound can be accurately determined. ✕ But when applied to soils other factors will greatly influence solubility, thus limiting the general application of such knowledge. It is mainly due to the above that so little value can be attached to an ordinary soil analysis where other knowledge of the soil type is lacking. ✕ The only possible value then of applying soil analyses lies in the empirical establishment of a working agreement between the solubility of mineral nutrients and response of a soil type to fertilization. In other words, it is essential to "back up" the chemical analysis with numerous field experiments and a knowledge of the feeding power of the crop along with an intimate acquaintance with other peculiarities of both the crop and soil type. Such a correlation has been established with considerable success on the sugar lands of Hawaii. ✕

This has been made possible by an extensive series of field experiments scattered over the island plantations and supervised by the Experiment Station agriculturalists. We thus had at our disposal soil samples of known fertility.

In Hawaii, approximately 225,000 acres are devoted to sugar cane culture. We are dealing with one crop and have, therefore, no concern for the wide variation in feeding power among different plants. There is involved only such variation as might exist between different varieties of sugar cane. While we have quite a wide variation in soil types, the lands cultivated to sugar cane involve only the lowland sections skirting the shore line of the islands. We have also the additional knowledge that under our continuous system of cropping there is an almost constant drain on the plant food nutrients and ✕ little opportunity for the natural agents such as aeration and fallowing to increase availability.

With a large number of field experiments available for studying the relation of soil analysis to soil fertility composite soil samples were collected from the experimental plots and phosphate and potash determinations made as follows:

PHOSPHATES.

Detailed methods of analysis are obviously outside the scope of this article. Suffice it to say that the following determinations were made: total phosphate present, that soluble in concentrated nitric acid, in concentrated hydrochloric acid, in one per cent citric acid and dilute nitric acid. A total of 39 soil samples was examined, taken from 23 field experiments located on 15 plantations and 4 different islands. There was no consistent relation noted between the first three determinations and response of sugar cane to phosphate fertilization. There was some relation in the results obtained with dilute nitric but with one per cent citric there appeared a notably consistent correlation. This relation is shown in condensed form in the following table:

Per Cent Phosphoric Acid (P_2O_5)	
In Soils Giving No Response	
Average . . . . .	.0493
Maximum . . . . .	.3190
Minimum . . . . .	.0030
In Soils Giving Response	
Average . . . . .	.0017
Maximum . . . . .	.0028
Minimum . . . . .	.0008

A detailed study was then made of the comparative solvent properties of citric acid from which in view of the fact that all soils containing less than .0030 per cent P_2O_5 soluble in one per cent citric responded to phosphate fertilization, it was suggested that this solvent merited considerable value as a measure of available phosphates in Hawaiian soils cropped to sugar cane.

POTASH.

In a set of 42 soil samples representing 14 field experiments on 13 plantations located on 4 islands, potash determinations were made as follows: total potash present, the solubility in concentrated hydrochloric acid, one per cent citric and dilute nitric acid. Here again one per cent citric was the only solvent showing any value. In those soils in which field experiments gave a response to potash the content as determined with one per cent citric varied from .009 to .023 with an average of .014 per cent. While those soils which gave no response varied from .031 to .082 per cent with an average of .054.

It is not suggested that these results give any evidence of two definite groups of phosphate or potash compounds, available and non-available but rather that they are present in different degrees of disintegration or availability. On the other hand, we do find in the specific case of coral impregnated lands larger amounts of calcium phosphates with the phosphates of iron and aluminum predominating in the normal island types. This in spite of the fact that the former are also high in iron and aluminum.

Also the general advocacy of one per cent citric acid is not suggested. Neither is any ordinary potash or phosphate determination by any definite method advocated. Numerous factors are involved in the availability of any mineral constituent of the soil and in interpreting the examination of plantation soils due consideration is allowed. This latter is the direct result of a further study of related factors in the soils from these experiments.

PHYSICAL COMPOSITION.

It is a well known fact that certain soil scientists attach considerable value to the relative size of the soil particles and plant food availability recognizing the influence of various salts upon soil aggregates. In clay soils there has been noted a certain restriction of root penetration. It is, therefore, generally conceded that plants may thrive on a smaller relative amount of plant food in a sandy soil. On the other hand, the greater relative surface exposure in a clay soil is a point in favor. This is especially true of salts which are highly concentrated or fixed in the film surrounding the soil particles. A consideration of the extent to which the above factor is involved in the availability of phosphate and potash showed that with the former there was no apparent relation between physical composition and availability in our soils. On the other hand, the higher clay content of the soils giving no response to potash was significant. The color of the island soils also appears to be a factor, the yellow types being almost uniformly low in potash availability as compared to the red.

SILICA.

Silica is classified in plant physiology among the so-called non-essential elements, yet sugar cane ash contains 50 to 60 per cent and Hawaiian soils are relatively high in soluble forms. The relation of silica to phosphate availability is, therefore, of interest. It was found that there was a marked relation between the solubility of silica and response to phosphate fertilization in that a greater availability of phosphate is usually associated with a higher solubility of silica and vice versa. There was also noted a close relation between the amount of phosphate assimilated, being greater where the silica was more soluble. On the other hand this factor appeared to be in no way related to the availability of potash.

LIME.

Frequent reference is noted in literature to the relation of lime and soil acidity to the availability of phosphates and potash. In a consideration of this factor results were obtained which are of no small interest. The high acidity of the soils deficient in both available potash and phosphoric acid, particularly the latter, is significant. The same was found to apply to lime, the high lime soils being higher in available forms of the above plant foods. Lime also appears to influence the assimilation of phosphate by the plant.

The application of soil analysis in determining the fertility of the sugar lands of Hawaii, interpreted upon this basis, is being applied with notably practical success, and it is suggested that similar working agreements are possible under similar conditions, that is, an intensive single cropping system confined to limited or definite areas. The interpretation is by no means infallible but in carefully considering all the related factors noted above which are associated with plant food availability and soil fertility the general application is highly successful. Field experiments are essential, of course, in establishing the analytical relationship.

Varieties at Kilauea

By J. A. VERRET.

EXPERIMENT 28, 1924 CROP.

EXPERIMENT 32, 1924 CROP.

We have recently harvested two experiments at Kilauea in which Badila, D 1135, Yellow Caledonia and Yellow Tip were compared. Two crops have been harvested, one plant and one ratoon.

In these tests the Badila did not show up very well as plant, but did very well as ratoons. The ratoon crop was much better than the plant. As a result of

the good ratoon crop the total sugar per acre for the two crops produced by the Badila was more than that of any of the other varieties.

The Yellow Tip also did very well, and is now being extended on this plantation; the total area planted to it now being slightly more than 350 acres (1924 and 1925 crops).

In Experiment 28, Badila, D 1135 and Yellow Caledonia were compared. The soil of this field in which these varieties were planted is heavy and comparatively unproductive. All fertilizations were uniform to all plots and comprised reverted phosphate and sand as well as nitrogen.

The results obtained from two crops are listed as follows:

YIELD PER ACRE.							
		Badila		Yellow Caledonia		D 1135	
Crop	Age	Cane	Sugar	Cane	Sugar	Cane	Sugar
Plant	22 mo.	27.9	3.30	34.1	4.00	35.7	3.55
1st Ratoon	16 mo.	37.0	3.95	27.2	2.59	29.5	2.24
Total (2 crops)...		64.9	7.25	61.3	6.59	65.2	5.79

All the cane in the plant crop was affected by rats, but the Badila suffered more in this respect than did the other varieties.

The results of Experiment 32 were similar to those of Experiment 28 in that although the Badila did not lead in the plant crop, it ratooned so well that the total for two crops was greater than that of the competing variety.

These results are reported more to show the behavior of the Badila rather than to compare with the Yellow Tip. Only one plot of Tip was harvested; the rest having been used for seed on account of the fine showing being made by this cane at Kilauea.

The Badila plant crop was badly rat eaten, while in the ratoons, the Yellow Tip suffered more from rat damage.

The results for two crops are given below:

YIELD PER ACRE					
		Badila		Yellow Tip	
Crop	Age	Cane	Sugar	Cane	Sugar
Plant	22 mo.	23.7	2.48	35.8	3.58
1st Ratoon	16 mo.	45.7	5.23	37.1	3.22
Total (2 crops).....		69.4	7.71	72.9	6.80

Neither Badila nor the Tips are ideal canes. Badila is too soft and brittle. It breaks easily in heavy winds and gives difficulty in milling on account of its pulpy nature.

Badila should be harvested before it gets too old. That is, we believe that two years is too long to grow Badila for best results in most places.

A serious difficulty of the Tip canes is their extreme susceptibility to mosaic and their lack of ability to withstand the disease when once contracted.

Realizing these weaknesses, we are devoting a great deal of attention to canes of this type in our breeding work, and by crossing with other varieties we hope to obtain canes more suited to our conditions. We feel that we are making progress. Our Uba crosses, especially, offer very promising material.

Variety Yields at Waipio

By J. A. VERRET.

WAIPIO EXPERIMENT "R," 1924 CROP.

A variety test was recently taken off at Waipio in which eleven different canes were compared. The crop was 22 months old, and had received a uniform application of 300 pounds of nitrogen per acre and 100 pounds of phosphoric acid from superphosphate.

The yields obtained are listed below :

Variety	Yield per Acre			Tons of Sugar per Acre Month
	Cane	Q. R.	Sugar	
H 109.....	99.4	7.81	12.72	.578
H 8952.....	95.5	7.81	12.23	.556
H 471.....	82.1	7.73	10.62	.482
H 472.....	96.2	9.29	10.35	.470
H 5974.....	73.3	7.27	10.08	.458
Waipio 5.....	84.1	8.37	10.04	.456
H 456.....	91.2	9.21	9.90	.450
H 465.....	79.7	8.65	9.21	.418
H 5923.....	64.4	7.74	8.32	.378
H 5919.....	67.6	8.71	7.76	.352
Badila	59.7	8.34	7.15	.325

Only one cane in the entire series proved a serious competitor of H 109. One of the 1918, H 109 seedlings, H 8952, produced about the same amount of sugar as did H 109. We do not regard H 8952 as the best of the "8900" series, so these results would indicate that in that series of H 109 seedlings we have canes as good or better than H 109.

Among these we would mention H 8958, H 8965, H 89102, H 8988, and H 8906.

None of the other canes can compare with H 109. Badila was very disappointing with a low cane yield and a rather poor juice.

H 472 and H 456 produced a heavy tonnage of cane, but their juices were poor.

In contrast to these results, these two canes are attracting some attention in the Hilo district and are being tried out rather extensively.

H 456 is also being planted to some extent on Kauai where several good yields have been obtained from plant fields. An interesting thing in this connection is the fact that the juices of H 456 are very good on Kauai, being better, in some cases, than H 109 juices. H 456 is somewhat weak as a ratooner. Some fields which we have seen are rather disappointing, although others are good. Before planting this cane at all extensively, its ratooning qualities in the different districts should be determined.

The Changes in Available Plant Food During the Growth of Sugar Cane

By W. T. McGEORGE AND G. R. STEWART.

The object of this investigation was to study the changes in available plant food in plantation soils during the growth thereon of cane crops; to determine the comparative value of water and one per cent citric acid as a measure of these changes, and to ascertain by means of these solvents the period at which the plant makes the heaviest drain on the plant food in the soil.

CHOICE OF SOILS.

The soils chosen were Field 45, Oahu Sugar Company, Koalipea section, at an elevation of 600 feet, and at the Waipio substation. The former is a reddish brown silt loam on which a phosphate test, Experiment 6, was being conducted. This soil responded markedly to phosphate applications but gave no response to potash. The latter is a yellowish brown silty loam on which Experiment V was being conducted and which has shown no response to either potash or phosphoric acid. A brief description of these experiments, taken from the files of the agriculturists, follows:

Experiment 6, Oahu Sugar Company. This experiment was started in 1916 (1918 crop) and was carried through three crops, one plant, one long and one short ratoon. The area is located in the upper fields of the Oahu Sugar Company, on the Waianae side of the government road. So far as is known, this was a virgin field being covered with a heavy growth of lantana and other weeds. The field was plowed twice during the year previous to planting. The object of the experiment and plan are illustrated in the following figure:

The harvesting results for the three crops as given in The Hawaiian Planters' Record, Vol. XXVI, p. 164, are reproduced herewith:

TABLE I.

Showing Harvesting Data on Three Crops from Experiment 6, Oahu Sugar Company, in Tons Sugar per Acre.

Plots	1918	1920	1922
A	8.74	14.01	....
B	8.17	15.46	5.64
C	8.40	14.29	5.66
X	7.07	12.38	3.01

The soil studies covered the second ratoon crop (1922). The first set of samples was taken February 7, 1921, the previous crop having been harvested in November, 1920. The fertilizer for this crop was applied three days after the first set of soil samples was collected.

Experiment V, Waipio Substation. This experiment comparing the value of nitrogen, phosphoric acid and potash was started in May, 1916, and has been carried continuously since. At no time has this experiment shown more than a slight variation from the different treatments. The plan of the experiment is best illustrated in the following figure. Nitrogen was, however, increased to 300 pounds per acre for the crop to which these soil studies apply:

The harvesting results for the five crops were as follows:

TABLE II.

Showing Harvesting Data on Five Crops from Experiment V, Waipio, in Tons
Sugar per Acre.

Plots	1917	1918	1919	1921	1923
A	6.20	5.80	6.08	9.31	15.24
X	5.88	5.77	5.84	9.17	14.96
B	5.86	5.76	5.82	8.64	14.57
X	6.06	5.95	6.10	8.88	15.12
C	5.52	5.99	6.17	9.25	15.04
X	5.73	5.83	5.80	8.95	14.67

The cane, during the first four crops, was Yellow Caledonia and D 1135. The 1923 crop, which the soil studies covered, was H 109 plant cane.

METHODS OF SAMPLING.

In a study such as that involved in this investigation, it is highly essential that every possible effort be made to obtain representative samples. Otherwise it is not possible to prove the slight variations, if existent. For this reason, two borings with a soil auger were made to a one foot depth in each row in every plot. For example, in Experiment 6 there were ten rows per plot and therefore a total of twenty borings was made, while, in Experiment V, with eight rows per plot, 16 borings were made. The borings from each plot were thoroughly mixed on a soil cloth and cut down to about ten pounds. This field sample was brought to the laboratory for analysis.

METHODS OF ANALYSIS.

In studying the changes in plant food during the period of these experiments, two solvents were used. In view of the fact that the principal agent of solution which the plant uses is carbon dioxide, we used, for the one solvent, water saturated with carbon dioxide. For the other solvent, one per cent citric acid was used. The methods are given in brief as follows:

1. Three hundred grams of soil without any preliminary drying was weighed into a two litre bottle, 1500 cc. of distilled water added and a stream of carbon dioxide gas passed through for 15 minutes. The bottles were then immediately stoppered and placed in an end over end shaking machine for three hours. The whole was then filtered through paper, the carbon dioxide effecting sufficient flocculation for rapid filtration and a clear filtrate. The following determinations

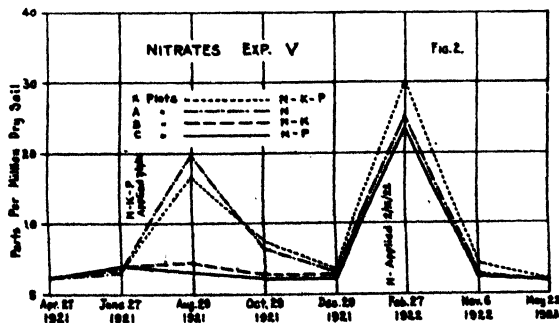
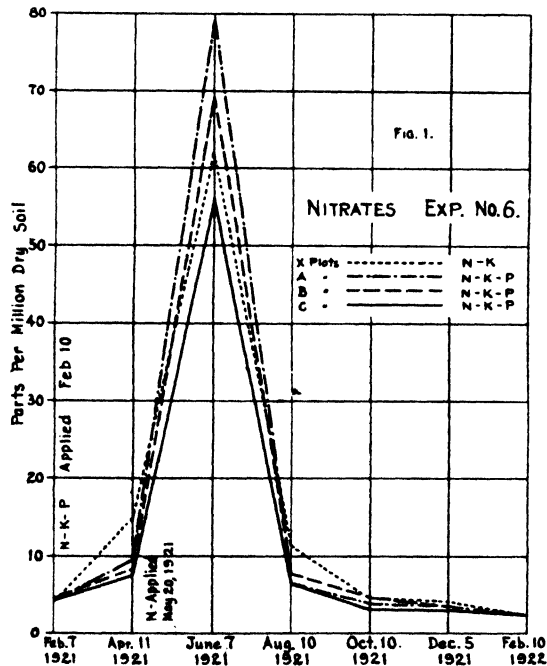
were made on this filtrate: Nitrite, nitrate, ammonia, calcium, potassium, phosphoric acid and total and non-volatile solids.

2. One hundred and fifty grams of air-dry soil was weighed into a two-litre bottle, 1500 cc. of 1 per cent citric acid added and the whole shaken in an end over end shaking machine for 6 hours. This was allowed to stand over night to settle, the supernatant liquor drawn off and filtered through paper. Moisture determinations were made on all samples and the results calculated to the water-free basis. The methods of analysis are described in Bulletins 47 and 48 of this Station.

Our results were calculated, in the water extracts, to parts per million water free soil soluble in water and per cent in water-free soil soluble in 1 per cent citric acid.

NITROGEN.

The two-month period of sampling was hardly often enough for a careful following of the rate of nitrate assimilation. The results of the analyses are shown graphically in Figures 1 and 2. The normal nitrate content of the two



soils is quite similar. In the Oahu Sugar Company soil the higher nitrate content was perceptible for approximately two months after fertilization. In the Waipio soil the results indicate perceptible amounts of nitrates to remain for a longer period, approximately three months in the first foot.

Nitrite and ammonia determinations were made at each sampling but at no time was more than a trace noted.

Of all the forms of mineral fertilizers added to the soil, nitrates are the only salts for which the soil does not possess definite fixing powers. The curves, therefore, show more rapid fluctuation and return to normal after nitrate applications.

PHOSPHATES.

Water Soluble. The seasonable variation in water-soluble phosphoric acid was very erratic. There was no increase in water-soluble phosphoric acid with fertilization although the results indicate a higher soluble phosphate content in those plots which had received phosphate than those receiving none. On the whole, definite deductions are not possible. The high phosphate content is significant at the ripening-off stage. The results indicate the heaviest draft on phosphate in the period of 2 to 10 months' growth with a cessation during the latter stages of growth.

Citric Soluble. Using 1 per cent citric acid as a solvent, some interesting and very significant results were obtained. They clearly indicate the greater demand for phosphates during the early stages of growth, 2 to 6 months' period, and the lesser needs during the ripening-off stage.

Also the value of this solvent in determining available phosphate is strongly apparent. In both experiments, the phosphate plots were higher than those receiving none. This is more strikingly true of Experiment 6 and illustrates the influence of soil type on the solvent action of citric acid. It is suggested that this difference may be in large part due to fixation as shown in Bulletin 47. In a study of the comparative absorbing power for phosphate by these two soil types, it was found that the soil from Experiment V possessed a higher fixing power for phosphate in the presence of 1 per cent citric acid and for this reason shows a lower increase in citric soluble phosphate after fertilization.

The results attach a greater value to 1 per cent citric acid than water saturated with carbon dioxide for measuring the changes in available phosphate in the soil.

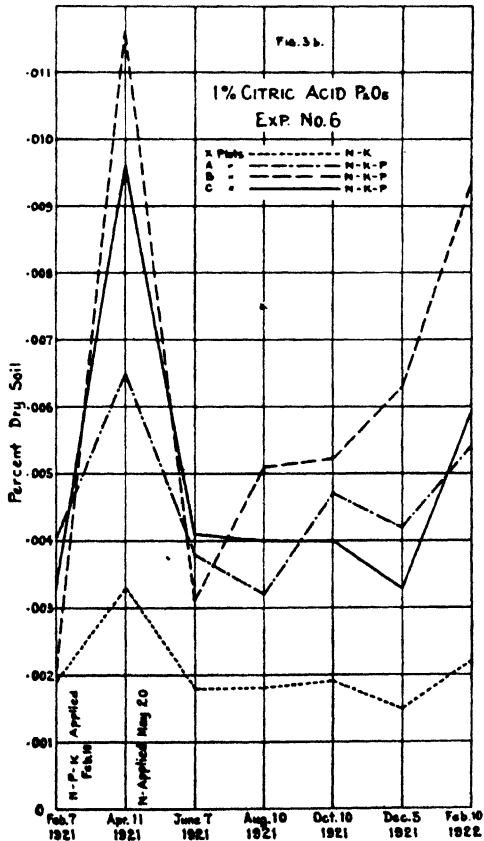
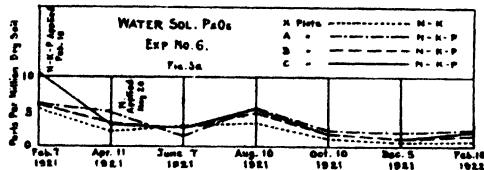
In order to determine whether this drop in citric-soluble phosphoric acid, especially in the Oahu Sugar Company soil, was due to assimilation and not to a loss from leaching or fixation in insoluble form by the soil, the following lysimeter experiments were planned. Two lysimeters were filled to a two-foot depth with soil from these two fields. Fertilizer applications were made as in the field and the lysimeters given a three-inch irrigation every two weeks. Soil samples were taken from each at two-month and four-month periods after application of fertilizer and phosphoric acid determinations were made, using 1 per cent citric acid as solvent.

TABLE III.

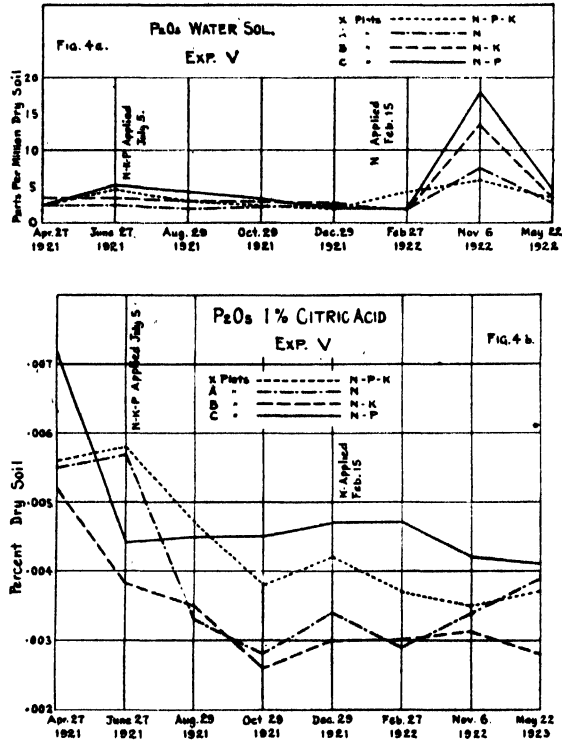
Showing Solubility of Phosphate in Lysimeters Receiving Phosphate and No Phosphate.

Fertilization	Soil	Two Months	Four Months
N-K	Experiment 6	.0019	.0029
N-K-P	Experiment 6	.0033	.0033
N-K	Experiment V	.0050	.0051
N-K-P	Experiment V	.0053	.0053

It is evident from the above that there is no loss in citric-soluble phosphate by fixation or leaching during the four months following irrigation and that the fluctuation in the curves in Figures 3a, 3b, and 4a, 4b is due to assimilation by the plant.



The greater removal of phosphate during the summer months is significant, from which there appears an association between the high growth degree months and demand for plant food. This is shown very strikingly in Experiment 6, the ratoon cane, and during the first season's growth of the plant cane in Experiment V.



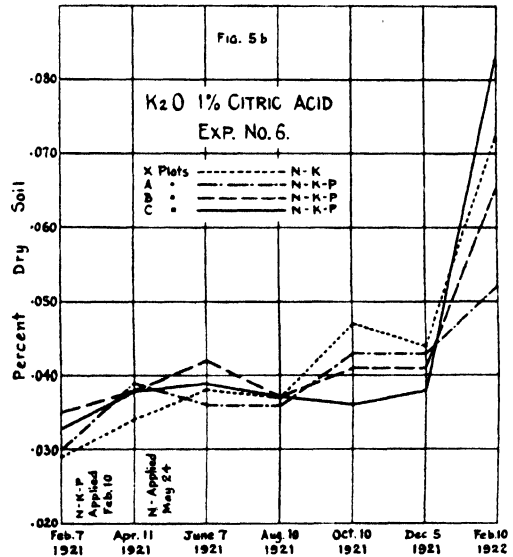
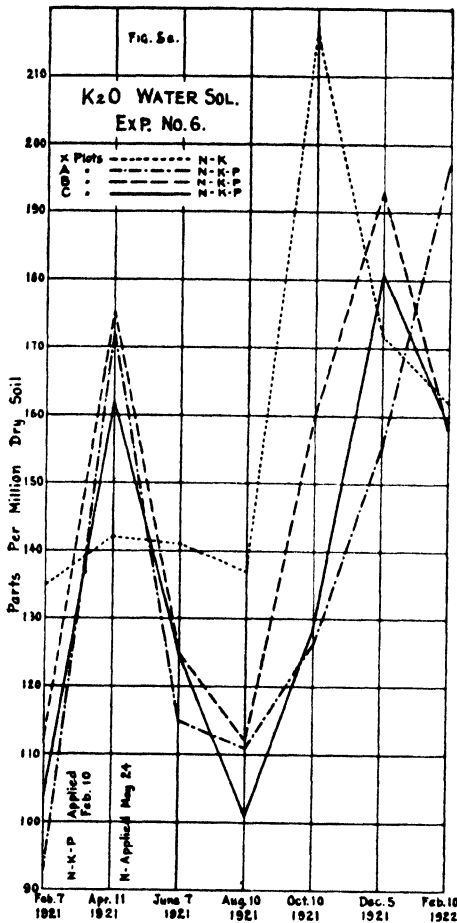
POTASH.

Both these soils have been shown to be amply supplied with available potash especially Experiment 6. The changes in available potash with cropping are indicated by Figs. 5a, 5b, and 6a, 6b.

Water Soluble. There was a marked increase in water-soluble potash after fertilization and a higher water-soluble potash in the plots receiving potash applications. The second to the eighth month seems to be the period at which the plant makes the heaviest drain on its potash supply. After this period there appears to be less demand. The potash-fertilized plots remain consistently higher throughout. There appears to be less demand for potash at least in the first foot of soil during the second season.

One Per Cent Citric Acid. In Experiment 6, all plots of which received potash applications, the curves for all follow the same general course. The available potash in the soil is very high and only during the fourth to sixth month is there any indication of a heavy draft on the available supply. In Experiment V, while the cane has shown no response to potash, the available supply is much lower than in the soil from Experiment 6. While the plots receiving potash applications are consistently higher than those receiving no potash, the

results are on the whole too inconsistent to allow any deductions, unless possibly the lower demand for potash during the latter stages of growth in the second season.



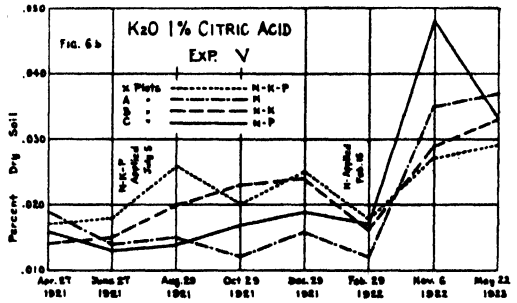
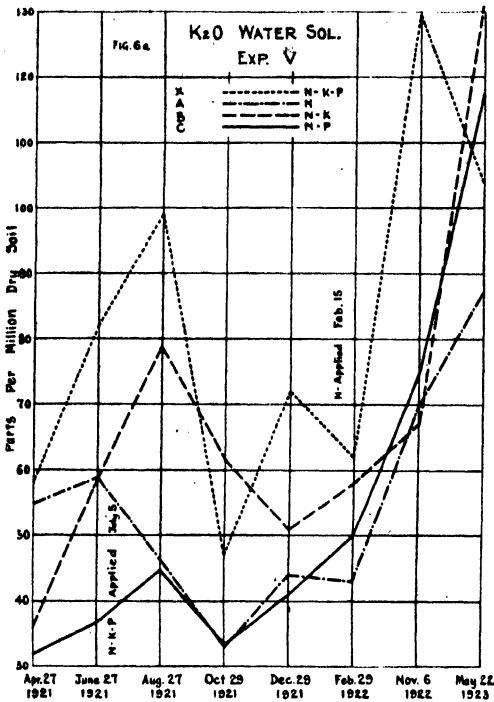
The curves in Figs. 5a, 5b, and 6a, 6b clearly show the value of citric acid for determining the differences in the available potash content of the soil. Water as a solvent is well adapted to studying the changes in potash during the growth of the plant.

The greater removal of potash during the summer months is also significant. The amounts present in water-soluble forms decrease notably during the high growth degree period. In other words, these results plainly show the lower drain upon plant food during the slow growth winter months and the relation between plant food requirements and rate of growth. Spring dressings supply the plant food to the crop at the beginning of its period of high growth degrees.

LIME.

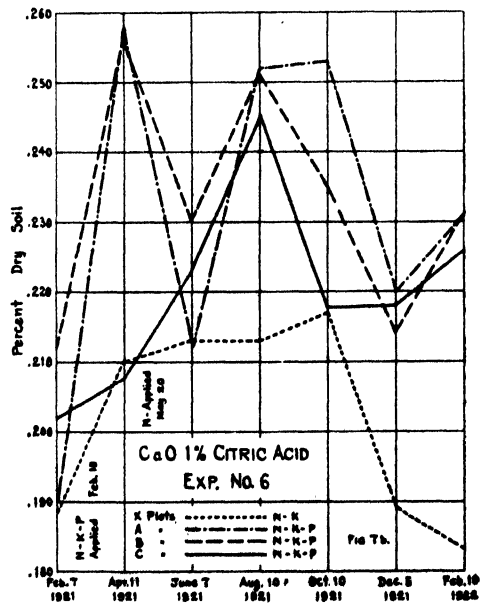
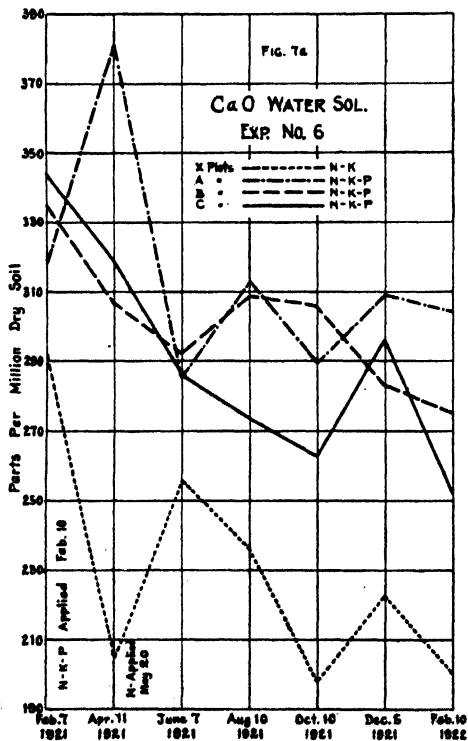
The changes in available calcium are shown in Figures 7a, 7b and 8a, 8b.

Water Soluble. There is considerable fluctuation in water-soluble lime. It is notably and consistently higher in those plots receiving phosphate applications. The greater draft on the lime supply also appears to be characteristic of the



early stages of growth becoming less so during the second season. Leaching may also, however, be a factor with this element.

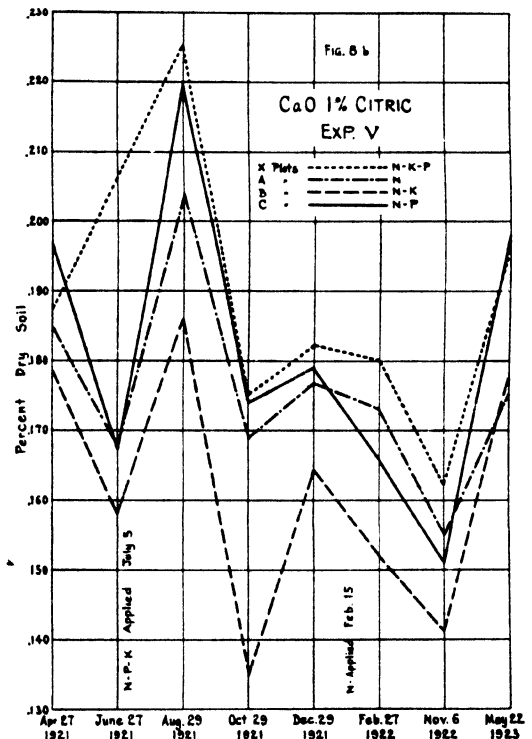
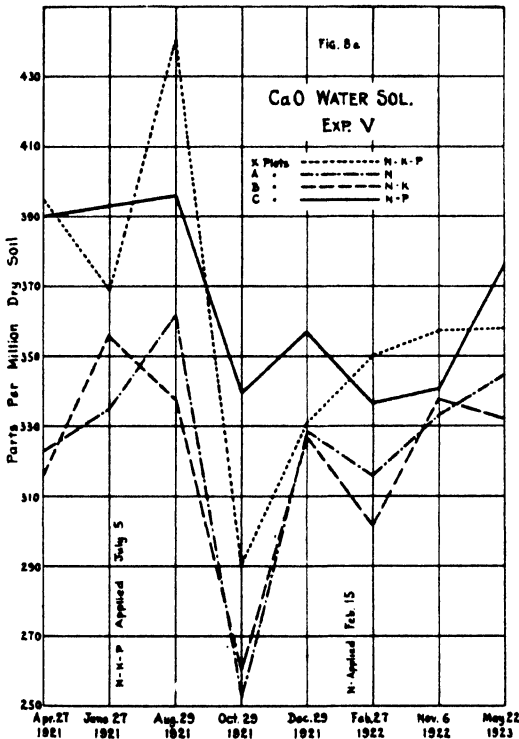
One Per Cent Citric Acid. The results obtained with this solvent are more consistent than in the water extract. The plots receiving phosphate are uniformly higher in available lime. There appears to be a decided decrease in lime during



both seasons. Citric acid is better adapted to measuring the changes in available calcium.

WATER-SOLUBLE SOLIDS.

The changes in total and non-volatile solids in the water extract followed the same general trend as noted under the individual forms of plant food. An increase immediately follows the fertilizer application followed by a decrease with cropping and leaching. Water-soluble solids, therefore, decrease with cropping. In Experiment 6, the A plots receiving the heaviest applications gave the highest solids, the X plots least. Both total and non-volatile solids were highest in the Waipio soil. See Figs. 9a, 9b, 10a, 10b.



EXPERIMENT 4, OAHU SUGAR COMPANY.

At the time Experiment 6 was being harvested, an adjacent Experiment, No. 4, offered an opportunity to apply the solvent properties of 1 per cent citric acid to a series of plots receiving increasing amounts of phosphate. The plan of the field experiment is given in the following figure:

Soil samples were taken from this experiment by the system already described and the analyses using 1 per cent citric acid as a solvent are given in the following table. A gain in yield of sugar was obtained from phosphate fertilization in this experiment:

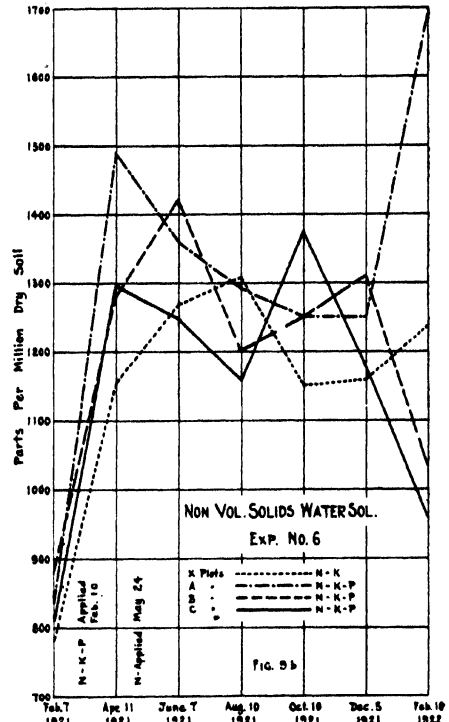
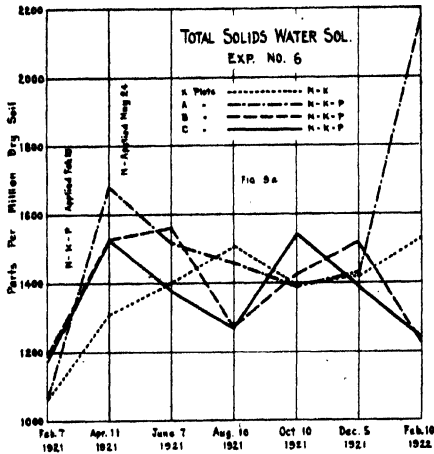
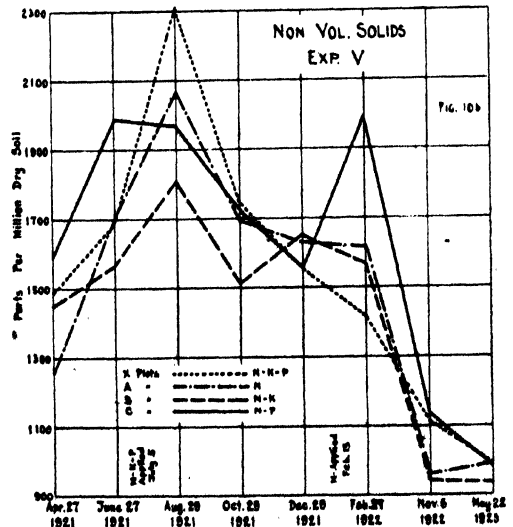
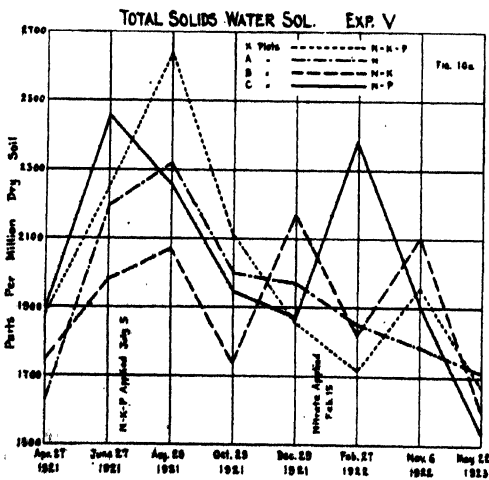


TABLE IV.

Showing Amount of Phosphate and Potash Applied in Experiment 4 and Solubility in 1 Per Cent Citric Acid as Per Cent.

Added to Soil		Per Cent in Soil			
P ₂ O ₅	K ₂ O	P ₂ O ₅	SiO ₂	CaO	K ₂ O
0	50	.0027	.088	.148	.050
60	50	.0039	.078	.154	.051
90	50	.0048	.084	.159	.052
150	50	.0078	.094	.188	.059
180	50	.0083	.089	.200	.050



Oahu Sugar Co. Exp. 4, 1922 Crop

Field 45.

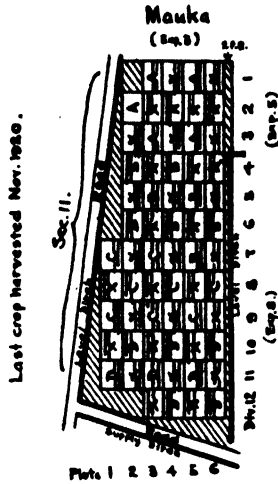
Fertilizer exp. (new land)

Phosphoric Acid requirements. Comparing 0, 60, 90, 120, 150, and 180 pounds per acre.

Cane - Lahaina & DHSS, 2nd ratoons, long (1/2 plot each)

Crop cane - N109, 2nd ratoons, long.

63 plots, each 1/2 acre (79.2' x 55') consisting of 20 single rows (or 10 double rows). Each single row = 1/20 acre. Each plot = 2 watercourses in width.



Areas : *

Exp. area = 6.30 A.

Crop Cane = 1.13 A.

Total = 7.43 A.

Note : *

This includes water-courses, add 2.5% for Level Ditches & straight Ditches.

Key :

□ = Lahaina
 ■ = DHSS
 ■ = N109

Fertilization - lbs. p.a.

Plots	F.F.	Jan. - Feb. 1921				Total lbs. p.a.		
		M.F.	Acid Phos.	Sulfate Potash	N.S.	N.S.	N.	P ₂ O ₅ K ₂ O
A	0	6640	0	100	91.9	565	175	90 30
B	0	795	109	100	0	565	175	90 30
C	0	795	255	100	0	565	175	120 30
D	0	795	441	100	0	565	175	150 30
E	0	795	620	100	0	565	175	180 30
F	0	795	805	0	0	565	175	120 0

J.A.Y.
 R.S.T.
 Y.K.
 Jan. 1921.

M.F. = Mixed Fertilizer 11% N.
 Acid Phosphate = 17% P₂O₅.
 Sulfate Potash = 50% K₂O.
 Nitrate of Soda = 15.5% N.

7% sulf.
 2% nitrate
 1% org.
 5% P₂O₅ (super phosphate)

While the changes during crop growth were not followed in this experiment, the data have been included to further substantiate the value of 1 per cent citric acid in measuring difference in amounts of available phosphate.

COMPOSITION OF CANE JUICES IN EXPERIMENTS 4, 6 AND V.

In order to determine the effect of fertilization upon the composition of the juices, samples of crusher juice were obtained from the cane from each plot of these three field experiments and analyzed with the following results:

TABLE V.

Showing Lime, Potash, Phosphoric Acid and Nitrogen Content of the Juice in Per Cent by Weight.

Experiment 4.

Pounds per Acre Fertilizer Applied			Per Cent In Juice By Weight			
N	P ₂ O ₅	K ₂ O	CaO	P ₂ O ₅	K ₂ O	N
175	0	50	.021	.0115	.177	.076
175	60	50	.028	.0138	.189	.050
175	90	50	.024	.0112	.226	.055
175	150	50	.023	.0139	.214	.054
175	180	50	.024	.0139	.222	.054

Experiment 6.

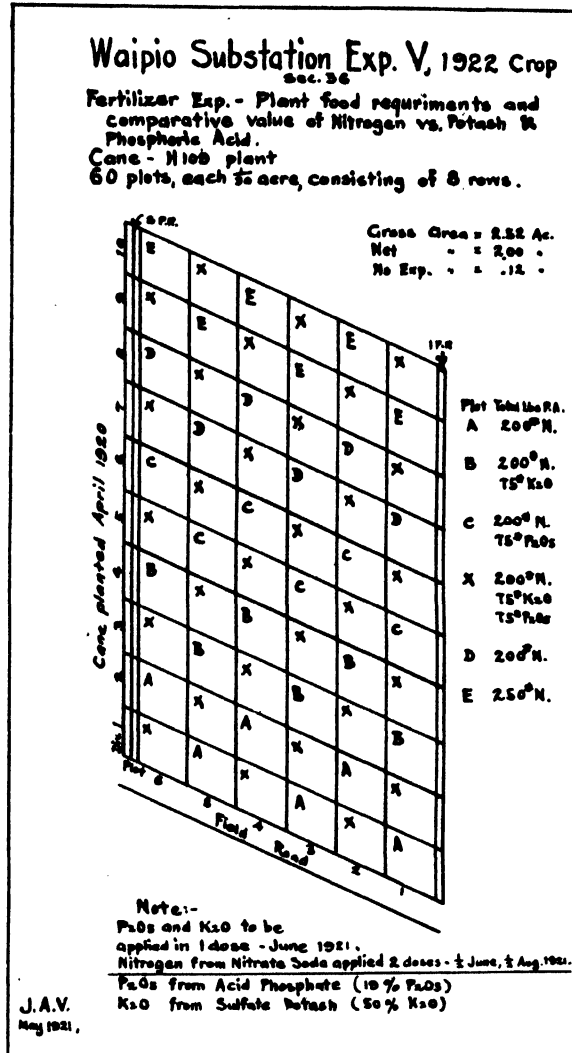
175	0	50	.026	.0082	.122	.077
175	180	50	.026	.0109	.140	.039
175	90	50	.021	.0107	.136	.032
175	90	50	.023	.0090	.111	.036

Experiment V.

300	0	0	.014	.0295	.122
300	0	75	.012	.0267	.141
300	75	0	.013	.0267	.120
300	75	75	.013	.0284	.131

It is significant that the juice from Experiment V, where no response was obtained, is notably higher in P₂O₅ than that from Experiments 4 and 6, both of which responded to phosphate fertilization. Strangely enough, there is little or no increase in the phosphate content of the juice brought about by phosphate fertilization. This is true in spite of the fact that a decided increase in sugar and cane yield was obtained in both. It indicates that factors other than the available phosphate present in the soil are involved in the assimilation of phosphate by the cane. While phosphate fertilization, where this element is deficient, may produce an increased yield and accompanying this an increase in total amount of phosphate assimilated, there is little or no increase in the actual phosphate concentration of the juice as is characteristic of the juice from plants grown on soils naturally high in available phosphate. Other investigations already reported from this laboratory have shown that the concentration of phosphate in the juice is related to the soil reaction and the forms of silica and lime present in the soil. There appears to be a slightly higher assimilation of phosphate by the D 1135 in Experiment 4 than the H 109 from the adjacent Experiment 6.

There is a greater concentration of lime in the juice from Experiments 4 and 6 than that from V. This is the direct opposite to the solubility in the soils using water as a solvent but agrees with the relative solubility in 1 per cent citric acid. It should be mentioned that the soil from Experiments 4 and 6 is highly manganimiferous. Pineapple plants grown on such soil types suffer a serious nutritional disturbance from an excessive assimilation of lime. It is possible



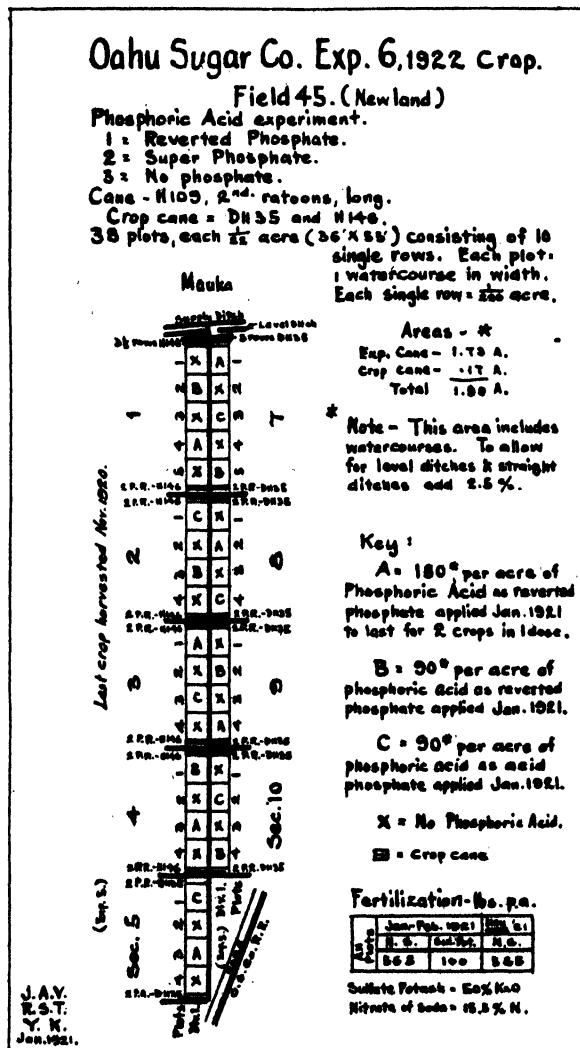
that a higher assimilation of lime by the cane on such soil types may be a factor in the above results. The cane having a higher lime requirement shows no chlorosis as does the pineapple.

In Experiments 4 and 6 all plots received the same amount of potash. The fields were adjacent fields and neither had given response to potash fertilization. It is notable, however, that the juice from Experiment 6 is much lower in potash. The cane grown in Experiment 4 was D 1135 and that in Experiment 6, H 109, which suggests a difference in feeding habits between the two varieties.

CONCLUSIONS.

The preceding studies bring out several points which have an important bearing upon the chemical work used to interpret soil fertility changes. Work carried on with mainland soils has indicated that water was possibly the most universally applicable solvent to use in following the changes in plant nutrients which occur during cropping. This will not hold for Hawaiian soils. Practically

all our soils contain notable quantities of the hydrated oxides of iron and aluminum. These colloidal complexes have notable fixing powers for practically all the plant nutrients. Even nitrates were found to be appreciably retained by soil columns in experiments previously published by one of the writers (1). It is doubtful if accurate determinations of water-soluble phosphates can be made in these soils even where a solution saturated with carbon dioxide is used as a solvent.



A dilute solution of citric acid, such as the one per cent strength employed in Dyer's method, appears to be best suited to study the changes in nutrients in the highly colloidal Hawaiian soils. Some fixation has even been shown (2) to take place from this solvent but it appears to be the best solution for determinations of the more available potash and phosphates. This conclusion agrees with the results obtained in two other investigations (2 and 3) carried on by one of the writers.

SUMMARY.

1. Determinations of changes in plant nutrients in the soil using water saturated with carbon dioxide showed that water was only suitable as a solvent for soil nitrates and to a lesser extent for potash.

2. One per cent citric acid was preferable for determinations of the effect of cropping upon lime; phosphates and potash.

3. Phosphoric acid was taken up in largest amount during the early stages of growth, 2 to 6 months with the ratoon crop which was under observation.

4. Potash was also taken from the soil in greatest amounts at an early period, namely, from the second to the eighth month of growth.

5. Lime was largely taken up during the first season, the demand for lime decreasing during the second season.

6. Determinations were made of the potash, phosphoric acid and lime in the juices of the cane harvested from two phosphate tests at Oahu Plantation and one phosphate and potash test at Waipio substation. The experiment at Oahu gave a response to phosphates but there was no appreciable increase in the per cent phosphate present in the juice from the fertilized plots. Potash gave no response in either experiment and the per cent in the juice was not increased by potash fertilization.

REFERENCES.

1. Absorption and Interaction of Fertilizer Salts and Hawaiian Soils. The Hawaiian Planters' Record, Vol. 26, p. 186.

2. A Study of the Phosphates in the Island Sugar Lands. Bul. 47, Agric. and Chem. Series, Exp. Sta. H. S. P. A.

3. The Availability of Potash in Hawaiian Soils. Bul. 48, Agric. and Chem. Series, Exp. Sta. H. S. P. A.

Bacterial Red Stripe Disease of Tip Canes*

BY H. ATHERTON LEE AND W. C. JENNINGS.

There is an old saying that an ounce of prevention is worth a pound of cure. There is no instance where this is more applicable than in the control of cane diseases; this is so fundamentally true that for each plantation, each district, and for the Territory as a whole, the first measure to be adopted for the control of cane diseases should be exclusion of new troubles.

A new cane disease, called red stripe, is occurring in the Kohala district on Yellow Tip, Striped Tip, and Red Tip canes. This circular is prepared for the purpose of advising plantations growing Tip canes in the Hamakua and Hilo districts on Hawaii, and those on Kauai and the other islands, of the appearance

* Originally published as Circular No. 42.

and nature of this trouble. With this information available, exclusion of red stripe disease from the plantations and districts not yet affected can be readily maintained.

Red stripe, being restricted to Tip canes, the total losses to the Territory resulting from it would not be large. However, losses on Tip canes from the disease may be expected to run from one to five per cent of the production per acre, possibly higher. The loss, even if less than one per cent, should be prevented, since it can be avoided at the present time with no cost to the plantations. It is good business to avoid losses from disease, no matter how small, for such losses are repeated annually. This is especially true when no investment is required in such prevention. Care in the prevention of this trouble will save money.

APPEARANCE OF THE DISEASE.

Red stripe disease is most noteworthy, and probably is of a more serious nature on young cane, from six inches to three feet high, than on old, well-formed cane. It is easily identified by the long, narrow, dark-red, longitudinal streaks on the cane leaves. These streaks usually start midway between the tip of the leaf and its juncture with the leaf sheath, at the point where the bend in the leaves of Tip canes takes place. The first indication of the disease is a watery darkened streak, not yet red, but still green, which spreads longitudinally up and down the leaf. This watery, dark-green streak gradually becomes bright red in color.

Such streaks are most commonly seen first near the midrib, then other longitudinal streaks usually follow farther from the midrib. In a few cases, the streaks may be seen along the edges of the leaves, but this is quite uncommon. Frequently the lower side of the midrib shows the longitudinal streaks, but seldom the upper side. The streaks are narrow, usually from $\frac{1}{2}$ to 1 millimeter wide ($\frac{1}{50}$ to $\frac{1}{25}$ inch); occasionally as wide as 2 millimeters, and sometimes coalescing, as shown in Plate 1, to give the appearance of a broad band 4 to 5 millimeters in width ($\frac{3}{16}$ to $\frac{1}{4}$ inch). The appearance of the disease is better understood from the photographs, Plates 1, 2, and 3, than from a written description.

These red longitudinal streaks, or the watery dark-greenish streaks which precede the red streaks, seldom pass the juncture of the leaf blade with the leaf sheath; in a few instances the lesions run down into the leaf sheaths, but only in very severe cases.

Infection does not seem to take place on the older leaves, but is seen more commonly on the middle-aged leaves. In severe cases, the young leaves, when still unrolled, are infected. Following heavy infection of such central leaves, a top rot of the cane frequently results, causing lalas to be put out and probably a lowering of the quality of the cane juices.

Leaves of cane approaching maturity are not as severely affected as the leaves on the younger cane; the red streaks are not as abundant on such older canes. In a few cases, however, when the red stripe leads to top rot, red streaks may be seen running down into the cane when it is split open; this probably also results in a lowering of the quality of the juices.

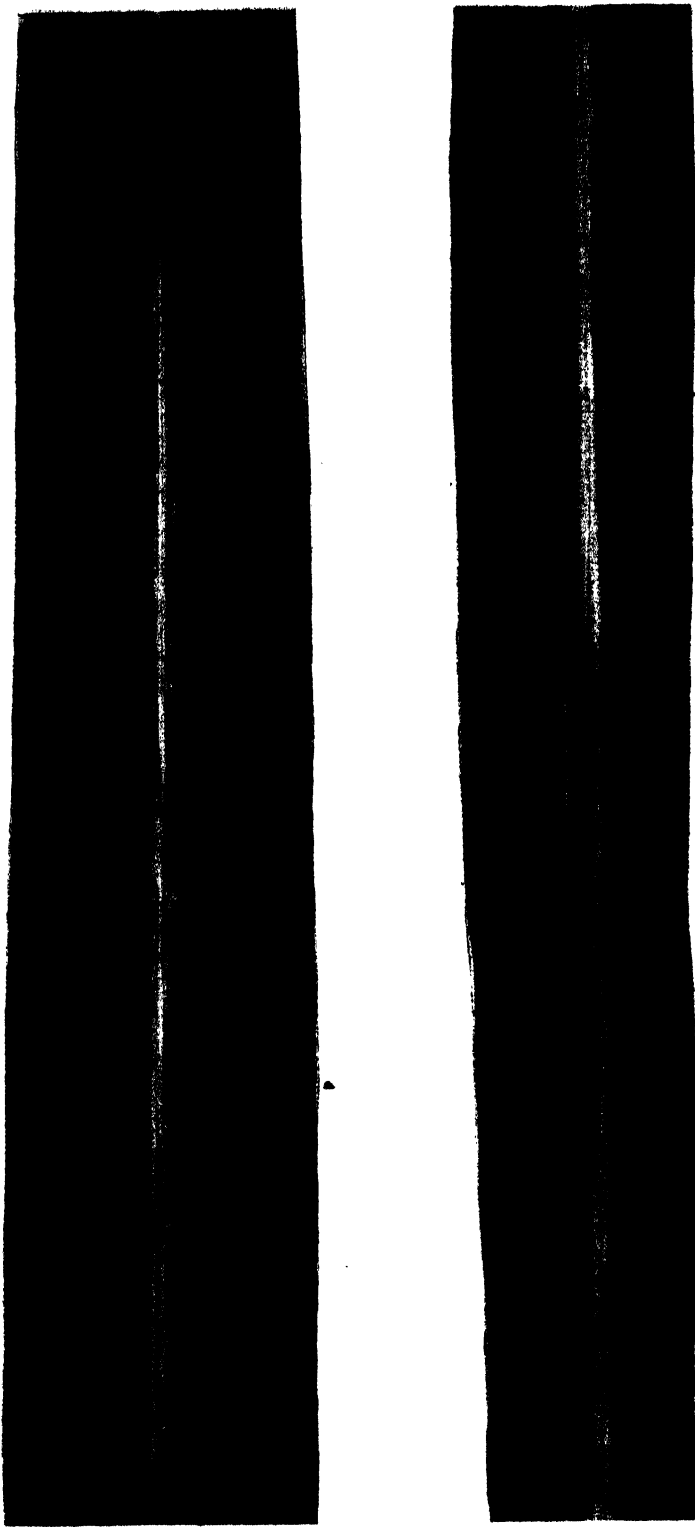


Plate 1.—Showing the dark-red, longitudinal streaks, in this instance on leaves of Striped Tip cane. The leaf on the right shows the streaks coalesced to such an extent that the green, actively-functioning part of the leaf is entirely destroyed.

Young cane shoots which are shaded by the older cane are usually more severely affected and frequently die out entirely from the disease.

Red stripe is usually much more severe on ratoons. Young shoots in ratoon fields frequently develop top rot when but a foot or two high and are killed back; this in some instances results in thinning out the stools to a considerable extent. This thinning out of young shoots in the stools is shown in Plate 3. Apparently young, active, vigorously growing leaf tissue is more susceptible than slow-growing, hardened leaf material.

VARIETIES AFFECTED.

Red stripe occurs in commercial plantings on Yellow Tip, Striped Tip, and Red Tip. A number of the native canes are also affected, some of them more seriously than the Tip canes. H 109 has never been observed to be affected. Rows of D 1135, Badila, and Yellow Caledonia, surrounded on all sides by affected Tip canes, have also shown a very high degree of resistance, although small but definite red stripe lesions have been observed in a single instance each on D 1135 and Yellow Caledonia. Cuttings of these canes, therefore, although resistant, would be a possible means of transporting the disease into uninfected districts.

CAUSE OF THE DISEASE.

Examination under the microscope shows the red streaks to consist of discolored, reddish-brown cells from which the chlorophyll bodies have disappeared. The cell walls of such browned tissues are greatly thickened. From such browned tissues frequently great masses of bacteria ooze out. Examination of cells apparently still normal, lying close to the discolored tissues, shows the presence of motile bacteria; these have been observed in the tracheal vessels and in the cells forming the sheath surrounding the vascular bundles.

Isolations have yielded bacteria which in preliminary studies have reproduced the disease on inoculation, while inoculations without these bacteria have remained healthy. The proof is very definite that the disease is caused by bacteria. The studies on this organism are progressing and it will be possible to give a more detailed account of the isolation and inoculation work as well as the description of the causal organism within a short time.

DISSEMINATION.

The observation has frequently been made in Kohala, that red stripe disease is usually slightly more general on the windward side of the field. It would be natural to expect such a bacterial disease as this to be disseminated to some extent by the wind, and this observation in a way corroborates this expectation. Other bacterial diseases are favored by wet weather; either rain or heavy dews forming a moist, dripping condition. Such a moist, dripping condition in the cane fields probably also favors the dissemination of red stripe.

On many of the watery-appearing, longitudinal stripes of affected cane, evidences of chewing insects were observed; such chewing is shown in the photograph in Plate 2. Apparently the juices of infected cells or tissues are peculiar in their odor or flavor and are attractive to such chewing insects. This, of course,

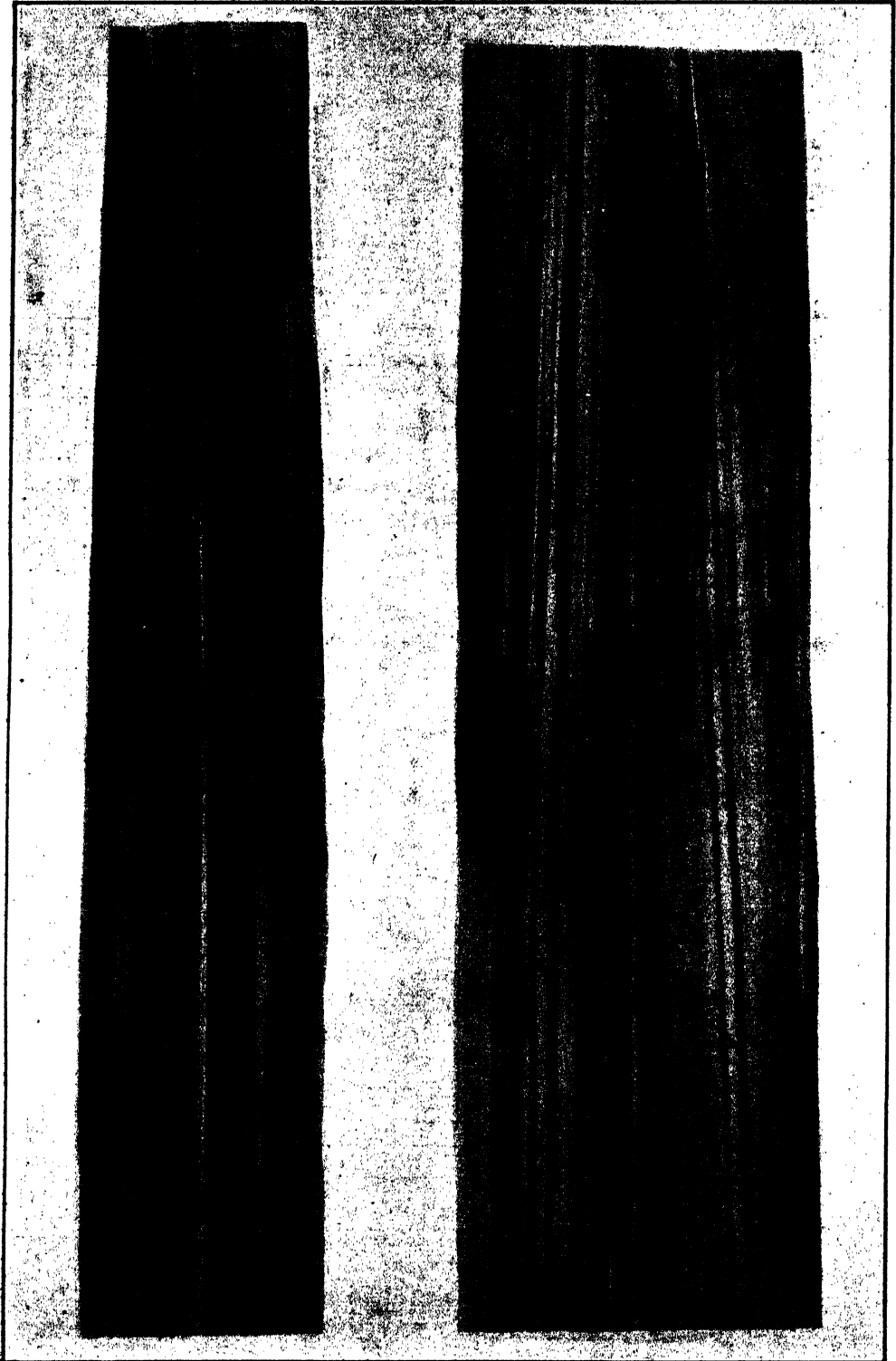


Plate 2.—Showing the dark-red, longitudinal streaks also on leaves of Striped Tip cane. Small areas can be seen where insects have been chewing in the watery streaks. This photograph shows the upper surface of the leaf, while Plate 1 shows the lower surfaces.

is immediately suggestive of the spread of the disease by chewing insects in addition to the agency of the wind and rain. Such a condition will be very difficult to combat in preventing the spread of infection in districts where it is already established.

There is also evidence to indicate that the disease is transmitted occasionally by cuttings.

CONTROL OF THE DISEASE.

For the plantations growing Tip canes on Kauai, and in the Hamakua, Hilo, and Kau districts of Hawaii, the cheapest control of the disease is exclusion. Exclusion involves no expense whatsoever, but necessitates discretion and the exertion of a little care on the part of individuals visiting the Kohala district.

Cane knives or pocket knives used in cutting cane of any nature in Kohala should be disinfected before being used in any other district. A solution of mercuric bichloride 1 to 1000, or a 10 per cent formalin solution, or a 2 per cent lysol or cresol would be satisfactory disinfectants for such use. One visiting Kohala and handling diseased canes should disinfect hands and arms and avoid contact of clothes, shoes, or hats with healthy cane outside of the district, until they have been laundered, washed, or disinfected in some way.

Although rather an extreme precaution, it is nevertheless advisable to avoid driving a car from infected fields into plantation roads in uninfected districts where the parts of the car would come into contact with the leaves or other parts of Tip canes. Field implements from Kohala should not be used on plantations having Tip canes, unless they have been disinfected.

No cane cuttings nor any parts of the cane or grasses of any nature should be carried from Kohala into uninfected districts. Related grasses, especially regarded with suspicion, are such plants as sorghum, broom corn, corn, Elephant grass, Sudan grass, etc.

A quarantine has been enacted by the Board of Agriculture and Forestry of the Territorial Government, penalizing, with a fine of five hundred dollars, the movement of any cane or any parts of cane or grasses from the Kohala district.

In the event of the disease breaking out through the neglect of proper precautions by individuals, plantations should be prepared to eradicate affected cane up to an area of five acres or even more. Such a measure would involve less loss than would result from the spread of red stripe throughout all the districts growing Tip canes.

In the Kohala district, ultimate control of the disease will be probable by the use of resistant Kohala seedling varieties of Tip and D 1135 parentage. With the determination of the causal organism, the susceptibility or resistance of these Kohala seedlings can be readily determined. There is reason to believe that among the Kohala seedlings which do well at high elevations, one or several will be found which are resistant. In the meantime, red stripe may be avoided and minimized, to some degree at least, by discretion in planting and fertilizing practices.

As an instance, it is becoming generally accepted that regardless of disease conditions, middle and mauka land fields in Kohala should be harvested and planted early, in order to give the young plant cane and ratoons the advantage of



Plate 3.—A ratoon field of Striped Tip cane at Kohala showing the leaves of the smaller shoots withered and killed out, and the resulting thinned-out appearance of the stools.

the best growing months in which to become established before cold weather. Bearing in mind that the cane is affected most severely when it is young, from 6 inches to 4 feet in height, anything which can be done to push the cane past this stage before the wet, cold weather of winter sets in, will also aid in minimizing the disease. Thus, where plantation conditions render it possible, early planting is especially desirable in the case of fields which have been infected with red stripe disease. If the cane is started before June, at the latest, by the time

the wet weather arrives, it has grown past the stage in which it is the most susceptible.

The proper timing of fertilizer applications will also aid in avoiding the disease. When the cane is planted early, applications of nitrogen shortly after planting will push the cane past the dangerous age by the time the wet weather favorable for infection arrives. With winter weather over, fertilizer applications will also be an aid in recovering lost growth due to the disease, if drought conditions do not prevail. Purely from the standpoint of the control of the disease succulent growth should not be forced out just prior to the winter season by fertilizers. Since, however, the success of fertilizers depends upon adequate moisture, it is hardly feasible in the Kohala district to withhold fertilizers on account of this disease, excepting possibly in rare cases of severe infection, where extreme measures might be used.

The inoculation of the Kohala seedlings to test for resistance and the gradual substitution of the resistant varieties will be, however, the most effective and satisfactory means of combating red stripe in Kohala. The prevention of the spread of the disease into Hamakua and Hilo and the other islands is the most economical means of combating red stripe outside of Kohala:

Chasing Bubbles in a Boiler*

An Outline of Where Steam Forms in a Boiler and the Path of the Water Circulation—Description of a Glass Model Boiler Used in the Study.

There are several hundred thousand engineers in charge of boiler plants who pride themselves in knowing all about boilers. If asked the question, "What is the water circulation in a boiler?" each and every one would have a very definite opinion, although the answers of any ten would not agree. Ask yourself this question and see how near your answer approaches the real facts as here outlined.

The wide divergence in opinion as well as the lack of actual information possessed by even those conceded to be the "knowing ones" in boiler design, was strikingly brought out in a contest instituted by the E. Keeler Company. Under the terms of the contest the engineer who described correctly the circulation in the horizontal return-tubular boiler was to be awarded a prize. Hundreds of engineers and engineering associations entered the contest, and the variety in answers almost equaled the number of contestants. A local of the National Association of Stationary Engineers won the prize, the answer, which was a composite of its members' opinions, being practically correct. Incidentally, some of the members actually constructed a glass model of the boiler before submitting their answer, and so were playing a "sure shot."

The widely differing opinions are not to be wondered at for the reason that whenever this subject has been touched upon by technical journals, a correct circulation has never been shown, and it may be mentioned that in recent text-books the circulation in return-tubular boilers is described in accordance with the previously accepted idea on the subject; that is, that the circulation path is upward

* Power, Vol. 59, No. 8.

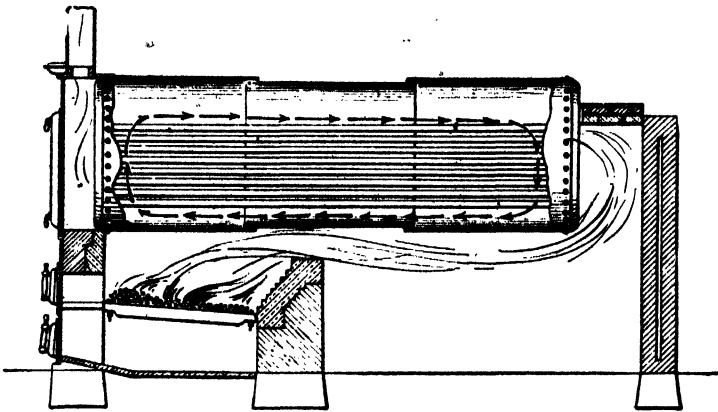


Fig. 1. Popular idea of how water circulates in a boiler.

at the front head, backward on the surface to the rear head, then downward at the rear, with a distinct forward circulation along the shell at the bottom, as shown in Fig. 1. After several years' experimental work, A. C. Lippincott, of the E. Keeler Co., succeeded in constructing a working glass model for demonstrating purposes before steam engineering organizations. The dimensions are to all intents in proportion to those of an actual boiler, and it is therefore possible to determine the circulation in a boiler of standard capacity.

Examination of the glass model shows that the water and steam mixture rises up along the front head, as indicated in Fig. 2, at a high velocity, and after releasing the steam bubbles, the water moves toward the rear until it reaches a point a little beyond the center of the boiler, whereupon it drops downward. Upon reaching the lower part of the boiler, the main part of the stream turns toward the boiler front, while a part flows toward the rear. There is a secondary

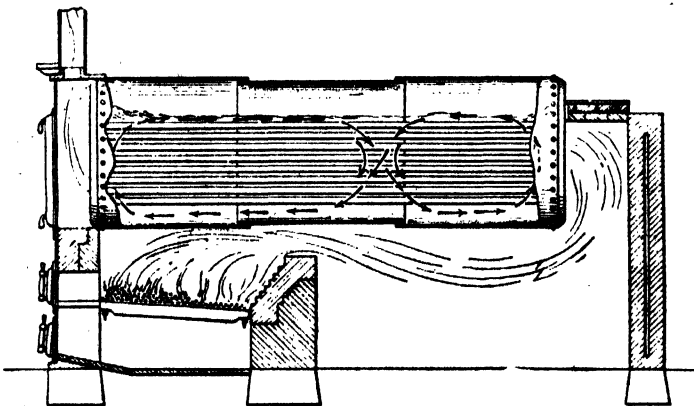
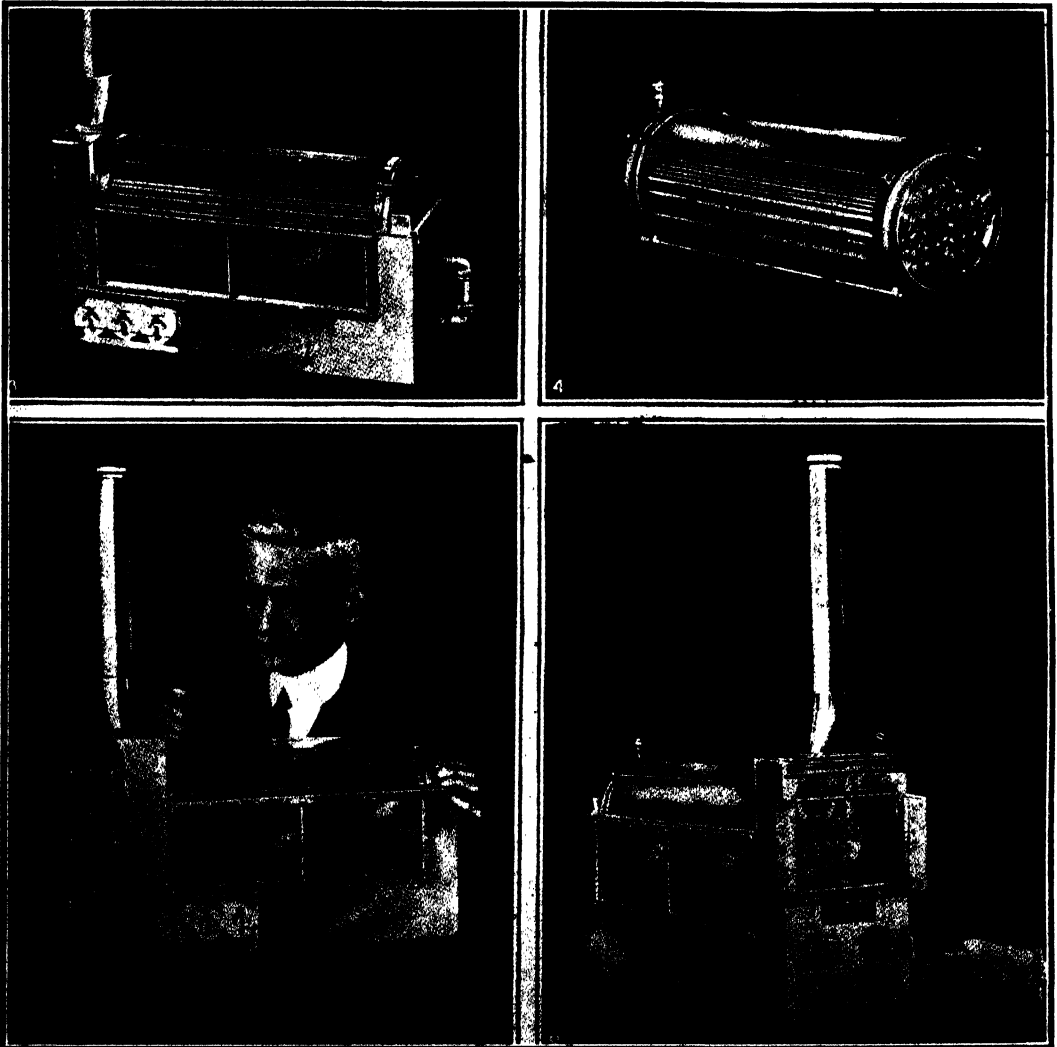


Fig. 2. Actual circulation as determined by study of a model boiler.

steaming zone at the rear head, causing an upward flow, the current then flowing toward the front and downward, making a loop. These two actions cause the circulation of the water to be in the form of a figure 8 placed horizontally thus, ∞ . The two streams interconnect as indicated in Fig. 2, but the major part of the steam bubbles are formed in the immediate vicinity of the front head.

Tea leaves placed in the boiler show that at the middle of the boiler, where the two streams cross, the circulation between any pair of tubes may be upward at one time, followed by a downward motion. The leaves also reveal that, contrary to the popular belief, there is no area of quietude in the boiler; leaves placed just above the blowoff are finally thrown into circulation. Likewise the argument that sediment will deposit on the belly of the boiler just above the bridge wall apparently has no basis, for the velocity of the water at this point is very high.

Strangest of the deductions to be made is that the water has the greatest ebullition along the front head. The front tube sheet is the coldest part of the boiler, much lower in temperature than is the rear tube sheet. It seems that the water immediately above the furnace absorbs heat rapidly and begins boiling. The upward circulation causes a flow of water from the rear, and the velocity set up is great enough to carry this water forward until it strikes the front sheet, whereupon the flow is upward between the tubes, the circulation shifting the natural upward path from being directly over the fire, to the front tube sheet. This is



Figs. 3 to 6. Views of model boiler.

so violent that the water is driven up against the top shell, incidentally showing that the steam and safety outlets should not be located well forward.

The circulation at the rear head is what is to be expected, since this part of the boiler is at a fairly high temperature. It may be stated with considerable accuracy that the greater part of the heat of combustion is absorbed by the boiler shell and that the gas temperature at the rear tube sheet is far below the furnace temperature.

An interesting experiment was conducted on the model boiler to determine the value of an external circulation tube placed in the furnace. For many years an occasional boiler has been fitted out with one or more "drop tubes" connected to the rear and front heads of the boiler by suitable fittings and passing through the furnace. The belief was that this pipe increased the boiler efficiency as well as the circulation. The model was equipped with one drop tube, as shown in Fig. 3, with a short section of gage glass in the circuit, and while no efficiency tests were run, it is significant that the pipe did lessen the time required to raise steam by 50 per cent. When steaming, the circulation was increased to a marked extent.

The Lippincott glass model boiler is shown in the illustrations on this page. The shell of the boiler, Fig. 4, is of pyrex glass, the heads of brass, while the tubes are of brass held into the front head by locknuts. External through bolts hold the heads, relieving the tube ends of much of the head pressure. The boiler setting or casing is of planished sheet aluminum, well insulated, and the front frame and doors are of cast aluminum, as is also the chimney. Three electric resistance coils supply the necessary heat, these being preferred to a gas flame. The type of heat apparatus does not alter the path of circulation to any extent, even when the flames of two gasoline torches are thrown into the furnace and against the rear "wall."

[W. E. S.]

The Performance Records of Some Individual Sugar Cane Stools

By A. D. SHAMEL.*

Object of the Study: This study was planned in 1922 for the purpose of (1) comparing the production of H-109 sugar cane grown in pukas with that

* In submitting this paper Mr. Shamel wrote:

"I recommend that this manuscript be published by the Experiment Station as a matter of record and for the use of those who are engaged in bud selection studies with sugar cane.

"I consider this study to be of fundamental importance in that it indicates the practicability of single-eye three-joint cuttings spaced five feet apart each way for individual stool study as a basis for intelligent selection work.

"The information secured in this study has enabled us to arrive at a satisfactory and intelligent conclusion as to methods for starting and growing individual stools of sugar cane for performance record study."

planted in trenches, (2) determining the practicability of using single-eye three-joint cuttings spaced five feet apart each way for experimental field work in general and bud selection studies in particular, (3) studying the comparative yields and habits of growth of a few of the apparently higher yielding progenies with the characteristics of a few of the apparently lower yielding ones, (4) securing information as to methods for carrying on systematic progeny tests under carefully controlled conditions for scientific study and observation, (5) making observations on the growth of the Uba variety as compared with H 109 where grown under similar conditions.

Location of the Experimental Plot: The experimental plot is located on the Experiment Station grounds in the west section of Makiki Field 7 and consists of a small area in the extreme northwest corner of this field.

Arrangement of the Experimental Plot: The plot was laid out with 9 rows of pukas beginning on the west side of the plot, followed by 4 rows of trenches and with an additional line of pukas on the east side as shown in the accompanying Map 1. The rows run north and south. The last line of pukas on the east side is not fully comparative with the remainder of the lines and the yields of cane in this row have not been used in calculating the comparative data as shown in the tables given in this report and are presented in a separate table of yields.

Puka and Trench Arrangement: The pukas are holes about $1\frac{1}{2}$ feet square, $1\frac{1}{2}$ feet deep and spaced approximately 5 feet from center to center in rows 5 feet apart. The trenches are the usual plant rows, 5 feet apart and with trenches in the bottom about $1\frac{1}{2}$ feet deep in which the cuttings were spaced approximately 5 feet apart.

Fertilization: The fertilization of the cane plants in this plot consisted of regular applications of a mixture of nitrate of soda and ammonium sulphate applied at monthly intervals beginning June 12, 1922, and ending September 12, 1923, 1924, making a total application of nitrogen at the rate of about 100 pounds per acre per month. At the time of planting, manure consisting of a mixture of stable manure and trash was mixed with dirt in the bottom of the pukas and trenches at the rate of about 9 bucketsful per stool.*

Irrigation: The irrigation of the cane in this plot was done with a garden hose and about 4 inches of water was applied at semi-weekly intervals from the time the cuttings were planted in April, 1922, and continued until December, 1923.

Handling the Plant Material: The plant material consisted of single-eye three-joint cuttings secured from eight of the H 109 progenies then growing at Waipio, two selected stools of H 109 from the plantation of the Oahu Sugar Company, 4 cuttings of Uba and one of the Lyman seedling. The cane stalks used for the plant material were about one year old. The seed pieces were cut with three joints, the two end eyes being gouged out with a knife leaving one good eye to each cutting.

Planting the Cuttings: The single-eye three-joint cuttings were first planted in small shallow boxes, those planted in rows 54 to 57 inclusive being started March 3, 1922, and those planted in rows 45 to 53 inclusive started April 8, 1922.

* The test was designed in part as an experiment in forced growth on widely spaced plants from single eyes, and was suggested by work of the Cuban Experiment Station along these lines.

MAP I. SHOWING ARRANGEMENT OF PROGENY TEST MAKIKI FIELD NO. 7.

Planted April to May 1922.
Harvested March 1924.

Figures on tops of squares indicate progeny numbers, in squares yield of stools in tons per acre and on left the row numbers.

57	P48 T.P.A. 274.42	P48 T.P.A. 206.91	P48 T.P.A. 145.05	P48 T.P.A. 184.69	P48 T.P.A. 175.98	P48 T.P.A. 167.71	P48 T.P.A. 152.02			
56	P48 T.P.A. 270.51	P48 T.P.A. 117.61	P48 T.P.A. 155.07	P48 T.P.A. 104.54	P48 T.P.A. 77.97	P48 T.P.A. 246.99	P48 T.P.A. 135.04	P48 T.P.A. 194.28		
55	P48 T.P.A. 255.70	P48 T.P.A. 128.07	P48 T.P.A. 160.30	S T.P.A. 95.40	S T.P.A. 110.64	Y T.P.A. 202.99	Y T.P.A. 184.69	P48 T.P.A. 228.69		
54	Y T.P.A. 253.52	Y T.P.A. 205.60	Y T.P.A. 165.53	S T.P.A. 142.44	S T.P.A. 193.41	S T.P.A. 196.02	S T.P.A. 238.71	S T.P.A. 233.04	S T.P.A. 360.67	
53	P156 T.P.A. 98.01	P156 T.P.A. 35.28	P156 T.P.A. 94.96	P156 T.P.A. 64.47	P156 T.P.A. 78.84	P156 T.P.A. 67.95	P156 T.P.A. 15.25	P94 T.P.A. 28.75	P94 T.P.A. 63.16	P94 T.P.A. 241.75
52	P155 T.P.A. 261.36	P155 T.P.A. 50.97	P155 T.P.A. 142.44	P155 T.P.A. 56.63	P155 T.P.A. 125.45	P155 T.P.A. 108.03	P155 T.P.A. 128.94	P155 T.P.A. 150.28	P155 T.P.A. 155.07	P156 T.P.A. 216.06
51	P153 T.P.A. 194.71	P153 T.P.A. 93.65	P153 T.P.A. 34.41	P154 T.P.A. 140.70	P154 T.P.A. 99.75	P154 T.P.A. 169.01	P154 T.P.A. 128.94	P154 T.P.A. 183.82	P155 T.P.A. 166.40	P155 T.P.A. 208.22
50	P142 T.P.A. 259.62	P142 T.P.A. 174.24	P142 T.P.A. 158.99	P142 T.P.A. 156.38	P142 T.P.A. 165.53	P142 T.P.A. 230.86	P142 T.P.A. 205.60	P142 T.P.A. 193.04	P153 T.P.A. 165.09	P153 T.P.A. 163.79
49	P63 T.P.A. 250.91	P63 T.P.A. 198.63	P63 T.P.A. 156.38	P63 T.P.A. 229.56	P63 T.P.A. 228.25	P63 T.P.A. 171.63	P94 T.P.A. 142.01	P94 T.P.A. 147.67	P94 T.P.A. 216.93	P94 T.P.A. 242.19
48	P155 T.P.A. 179.90	P155 T.P.A. 63.60	P155 T.P.A. 131.99	P155 T.P.A. 127.20	P155 T.P.A. 23.09	P155 T.P.A. 82.76	P155 T.P.A. 104.54	P156 T.P.A. 109.34	P156 T.P.A. 72.75	P156 T.P.A. 182.95
47	P142 T.P.A. 191.23	P142 T.P.A. 19.17	P142 T.P.A. 91.91	P142 T.P.A. 13.94	P142 T.P.A. 54.85	P142 T.P.A. 26.14	P154 T.P.A. 86.68	P154 T.P.A. 47.48	P154 T.P.A. 114.56	P155 T.P.A. 94.09
46	P142 T.P.A. 214.33	P142 T.P.A. 123.71	P142 T.P.A. 110.21	P142 T.P.A. 118.92	P142 T.P.A. 53.14	P142 T.P.A. 50.97	P142 T.P.A. 62.73	P142 T.P.A. 55.32	P142 T.P.A. 82.83	P142 T.P.A. 133.73
45	P63 T.P.A. 218.67	P63 T.P.A. 361.55	P63 T.P.A. 226.51	P63 T.P.A. 186.44	P63 T.P.A. 265.72	P94 T.P.A. 240.89	P94 T.P.A. 154.20	P94 T.P.A. 127.20	P142 T.P.A. 202.77	P142 T.P.A. 150.28
Row 44	X T.P.A. 68.82	P142 T.P.A. 129.81	P142 T.P.A. 138.96	P142 T.P.A. 165.09	P142 T.P.A. 184.64	P155 T.P.A. 168.59	P158 T.P.A. 107.59	P63 T.P.A. 62.73	U T.P.A. 260.92	U T.P.A. 203.43
									U T.P.A. 187.31	U T.P.A. 290.98

A.D.S.
Mar. 1924.

The cuttings of H 109 and Lyman seedling for planting in row 44 were started in boxes during April, 1922, while the Uba cuttings were started on June 30, 1922. Good strong seed pieces were used in all cases.

Transplanting the Cuttings: The cuttings were grown about one month in the germinating boxes and then transplanted to the field plot. The transplanting was done during April, May and June, 1922, with the exception of the Uba cuttings which were transplanted July 11, 1922.

Growth Measurements: Systematic growth measurements were carried on with stalks of selected stools in order to show the rate of growth of the plants during the different seasons throughout the entire course of this experiment.

Cut-out Stools: Of the total 129 stools planted for comparative study, two H 109 stools, 47-3 and 55-2, were cut out in June, 1923, for new progeny tests and one H 109 stool, 45-3, was taken out on account of mosaic disease, leaving a total of 126 stools in addition to those in the outside row on the east side of the plot.

Parentage of the Progenies: The progenies used in this study were designated by numbers and symbols as follows: P 48, S, V, P 156, P 153, P 94, P 155, 154, P 142, P 63, X, and V. Those with P (abbreviation of progeny) followed by numerals designated the Waipio progenies, S and V the two selected stools from Oahu Sugar Company plantation, X the Lyman seedling,* and U the Uba variety.

The parent Oahu Sugar Company stools were selected on account of their development of a large number of uniformly good stalks indicating inherently desirable characteristics. The Lyman seedling stool was grown from a cutting of a stool of this variety grown on the Olaa plantation. The Uba cuttings were secured from a stool of this variety grown at Makiki.

Causes of Reduced Yield: Considerable loss of crop, including dead and broken, stolen, rat-eaten, borer- and termite-injured stalks, blown over and uprooted stools, which developed in this plot might have been avoided in part at least if the plants had been harvested at the end of a sixteen or eighteen month period. However, it was deemed advisable to grow the plants for two years in order to ascertain the facts concerning the rate of growth, habit of growth and eye development of the plants during this period. The loss from the causes noted above is estimated to have been more than 25 per cent of the total final weight of crop.

Harvesting: The harvest of the cane plants in the plot was begun March 6, and was finished March 20, 1924.

Each stool was harvested separately. In a few instances each individual stalk of the stool was cut, weighed, measured and its performance record data recorded. In most cases, however, the second season stalks in each stool were cut first and the data secured from their study recorded after which the first season stalks were harvested and studied with a systematic record of some of their characteristics. The plan of harvest procedure was as follows:

(1) The second season stalks were cut and any dead or stolen ones counted. The number of healthy stalks was determined as well as their average length, their total weight, the number showing evidence of borer injury and damage from breaking or mechanical injury and the number of tasseled stalks. Special notes were made where necessary concerning unusual conditions, e.g., rat or termite damage, lala development, dead tops and as to the uniformity of stalks in particularly good stools.

(2) The first season stalks were cut and the number of dead or stolen stalks recorded. The number of healthy first season stalks was then counted, their average length recorded together with their weight, the number of stalks attacked

* This variety was cut for seed in 1923, so the data concerning it may be disregarded.

by borers and those broken or tasseled. Similar notes to those secured from second stalks were obtained from first season stalks as opportunity offered. The second and first season stalks were kept separate until the performance record data were secured.

(3) From a few apparently good stools in all of the progenies, composite samples of stalks from both the second and first season stalks were taken for chemical analyses of the juice and the determination of the quality ratio. In this work damaged stalks interfered with securing uniformly satisfactory results.

(4) Owing to the age and condition of the stalks little good seed was available and it was generally agreed to secure desired seed from the ratoon growth. However, top growth seed-pieces were cut from some of the stalks in a few stools of several progenies and placed in germination boxes.

(5) The yield expressed as tons per acre was calculated for each stool by multiplying its weight by the factor .8712. This ton per acre figure simply shows the yield of each stool on a 25 square foot area, or 1/1742.4 part of an acre, calculated to the acre basis. No reduction or other adjustment to plantation conditions was attempted, and these figures were used in order to more graphically represent the comparative stool and progeny yields.

Table 1 shows the summary of the yield data for all progeny planting except that in the outside row on the east side. In this table the number of stools harvested in each progeny is given, followed by the averages for each characteristic recorded. The performance record data for the progenies grown in pukas is given first in a group and those grown in trenches as another group. The performance record averages of two inside rows of puka plantings is next compared with the performance record averages of two inside rows of trenches. Next the average data for all puka and trench planting shown in Table 1 is presented. The average weight per stalk and average weight per foot of stalk for all stalks is shown.

The puka average yield as shown in Table 2 is 163.10 tons per acre with an average quality ratio of 10.32.

The trench average yield as shown in Table 2 is 144.51 tons per acre with an average quality ratio of 9.30.

The average yield of the two inside rows of puka planting as shown in Table 2 was 164.68 tons per acre as compared with the average yield for the trench planting of 101.23 tons per acre.

The average yield for both puka and trench plantings as shown in Table 2 was 156.12 tons per acre with an average quality ratio of 10.05.

The average weight per stalk in both puka and trench plantings as shown in Table 2 was 10.88 pounds and the average weight per foot of stalk was .606 pounds.

In Table 3, the progeny comparative average yields in tons per acre and average quality ratio is shown arranged in the order of yields.

TABLE I.

SUMMARY OF PROGENY PERFORMANCE RECORD DATA.

No. of Stools.....	Progeny.....	Average No. Healthy Stalks..	Average No. Healthy Plants..	Average No. Dead Stalks.....	Borer.....	Mech.....	Tassel.....	Average Length..	Q. R.....	T. P. A.....	Notes.....
19	48	16.32	205.77	6.68	8.32	2.53	4.77	16.96	10.11	179.26	Puka
8	S	20.13	232.44	5.50	8.12	4.00	4.25	18.40	9.89	202.49	"
5	V	18.20	215.30	8.00	9.00	1.80	2.66	17.90	10.93	187.66	"
7	156	9.40	107.50	4.70	4.00	1.50	2.50	18.20	11.10	93.65	"
5	153	13.00	149.60	4.60	5.00	1.80	3.20	18.40	11.68	130.33	"
9	94	15.70	174.30	4.70	7.00	2.20	5.00	18.50	10.02	152.85	"
11	155	13.36	162.14	4.36	6.27	1.33	4.33	19.00	13.32	141.25	"
5	154	12.20	165.80	3.20	5.20	1.00	5.00	19.40	9.37	144.46	"
8	142	16.60	221.70	2.00	7.00	2.00	4.75	18.10	9.73	193.13	"
6	63	18.80	236.60	3.60	9.50	1.60	7.00	18.40	.....	205.89	"
<hr/>											
83											
Total	...	153.71	1871.15	47.34	69.41	19.76	43.46	183.26	.....	1630.97	"
Average.		15.37	187.12	4.73	6.94	1.98	4.35	18.33	10.32	163.10	"

Trench Planting

3	94	21.70	199.80	4.70	8.70	8.00	4.00	16.50	.....	174.09	Trench
8	155	12.00	115.81	11.25	7.00	3.42	2.71	17.73	13.60	100.89	"
3	154	11.33	93.17	8.00	9.00	10.70	3.00	19.90	.....	82.91	"
19	142	11.40	120.66	10.95	5.77	2.95	5.54	16.96	9.50	105.14	"
5	63	25.40	289.00	3.33	5.40	4.75	7.40	16.90	8.74	251.78	"
5	156	18.50	174.80	12.60	10.00	4.50	5.25	16.02	14.06	152.29	"
<hr/>											
43											
Total	...	100.33	993.24	50.83	45.87	34.32	27.90	104.01	.....	867.10	"
Average.		16.72	165.54	8.47	7.64	5.72	4.65	17.33	9.30	144.51	"

Puka vs. Trench Planting—2 Inside Lines of Each

142, 153,											
20	154, 155	14.9	189.03	3.26	6.35	1.92	4.58	18.38	.....	164.68	Puka
142, 154,											
22	155, 156	11.86	116.16	11.05	6.90	4.00	5.19	16.86	.....	101.23	Trench

Average for All Progenies.

126 stools	15.88	172.71	6.14	7.21	3.38	4.46	17.95	10.05	156.12	
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TABLE II.

PUKA AND TRENCH AVERAGE YIELDS.

No. Stools	Kind of Planting	Tons per Acre
83	Puka	163.10
43	Trench	144.51
126	Puka and Trench	156.12
20	Two comparative lines of Puka	164.68
22	Two comparative lines of Trench	101.23

Average weight per stalk 10.88 lbs.

Average weight per foot of stalk606 lbs.

TABLE III.

PROGENY COMPARATIVE AVERAGE YIELDS ARRANGED IN ORDER OF YIELDS PER ACRE.

Puka Planting.

Rank	Progeny	No. of Stools	Tons per Acre	Q. R.
1	63	6	205.89	8.91
2	S	8	202.49	9.89
3	142	8	193.13	9.73
4	V	5	187.66	10.93
5	48	19	179.26	10.11
6	94	9	152.85	10.02
7	154	5	144.46	9.37
8	155	11	141.25	13.23
9	153	5	130.33	11.68
10	156	7	93.85	Not taken
Average yield			163.10	10.32

Trench Planting.

1	63	5	251.78	8.74
2	94	4	174.89	Not taken
3	156	5	152.29	14.06
4	142	19	105.14	9.50
5	155	8	100.89	13.60
6	154	3	82.91	Not taken
Average yield			144.51	9.30

It will be noted in Table 3 that the higher average quality ratios are usually correlated with the best yielding progenies and the lower quality ratios are correlated with the poorer progenies. This is a fundamentally important consideration. It appears to be a somewhat similar condition to that found in citrus fruit improvement work where high yields within the variety are usually correlated with the best commercial quality.

In Tables 4 to 12 inclusive, the yields of the individual stools of each progeny are presented. The yields of the puka stools have been grouped separately from

those of the trench stools. The total and average figures for each group have been determined for comparative purposes.

It will be noted that of the ten progenies grown in pukas only six were grown in the trenches. Furthermore the number of stools of each progeny in each kind of planting varies, the maximum number being nineteen while the minimum number is three. It is also obvious from a study of the arrangement of the progenies in the plot as shown in Map 1 that there is a larger proportion of outside to inside stools in some progenies than in others. In addition to these difficulties in making accurate progeny yield comparisons the plan of planting did not provide for the systematic repetitions of each progeny in different parts of the plot.

In Table 13, the performance record of the outside row of stools in the east side of the plot is given. This row has not been used in comparing progeny behavior from the fact that the planting was done at a widely different time from that of the remainder of the plot, for the reason that the young plants of the H 109 progenies used for planting were those which had survived drought and neglect in the germination boxes, and to extreme differences of environment and other conditions in the row. For example, in stool 44-8 of P. 63, the stalks were completely overshadowed by the adjoining stools of Uba. Furthermore, at some time several stalks of this stool had been taken out and their weight lost as they could not be found at the time of harvest. The main item of interest in this row is the performance record of the four stools of Uba showing an astonishingly high yield both in number of stalks per stool and total weight of stalks.

In Table 14, the comparative progeny yields computed to tons per acre are shown as percentages above or below the average. This table shows the superior yielding characteristics of Progenies 63, 142, S, V, 48, as compared with Progenies 153, 154, 155. The yield of Progeny 94 is slightly below the average in the pukas and considerably above it in the trenches, while the yield of Progeny 156 is very much below the average in the pukas and slightly above it in the trenches. From careful observation of the characteristics of the individual stools of these two progenies during harvest, the indications were that P. 94 was a somewhat superior progeny while P. 156 was an inferior one.

In Table 15, the performance records of two rows of puka stools are compared with two rows of trench stools. It is believed that this table gives a more accurate measure of comparative puka and trench stool behavior than where all of the puka and all of the trench stools were used for this comparison. It will be noted that the average yield of the puka stools was at the rate of 164.68 tons per acre while that of the trench stools was 101.23 tons per acre. It will also be seen that there was an average of 3.26 dead stalks in the puka stools as compared with an average of 11.05 dead stalks in the trench stools. The number of borer-damaged stalks noted in the pukas averaged 6.35 stalks per stool as compared with 6.90 in the trench stools, a practically even condition in this respect. The average number of mechanically injured or broken stalks in the puka stools was 1.92 while in the trench stools it was 4.00 indicating much greater wind or other damage in the trenches than in the pukas as illustrated in Figs. 1 and 2. The average number of tasseled stalks noted in puka stools was 4.58 while in the trench stools the average number of tasseled stalks was 5.19, practically the same



Fig. 1. Puka stools showing better supported and less damaged stalks as compared with the trench planting.

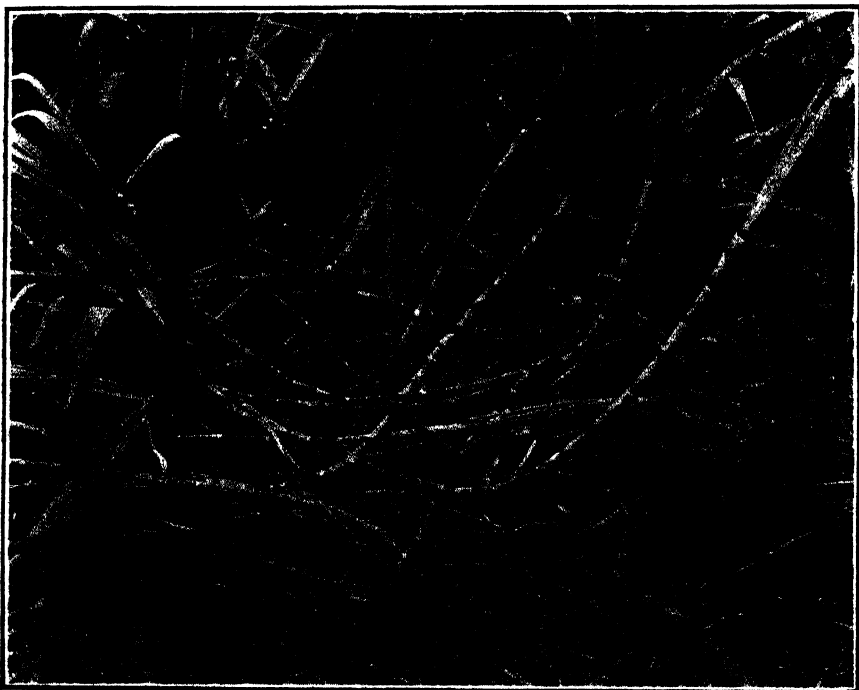


Fig. 2. One of the rows of trenches running north and south, showing very recumbent and damaged condition of stalks typical of the stools in these rows.

under both conditions. The average length of stalks in the puka stools was 18.38 feet as compared with an average length of 16.86 feet in the trench stools.

In Table 16, is shown the percentage of dead stalks in each progeny, of dead stalks in pukas and trenches, and above or below the average in pukas and in trenches. It will be noted that there was an average of 23.58 per cent dead stalks in the puka stools as compared with an average of 34.67 per cent dead stalks in the trench stools. The average percentage of dead stalks in all puka and trench stools was 27.78 per cent. The stalks in the puka stools showed a more frequent tendency to lala. It is also apparent that there was a smaller percentage of dead stalks in Progenies 63 and 94 than in others.

In Table 17, is shown the percentage of stalks noted with borer damage in puka as compared with trench stools, and the percentage of borer-injured stalks in each progeny as well as the percentage above or below the average in puka and trench plantings. The average per cent of borer-injured stalks in puka stools was 34.25 while that for trench stools was 31.07. There is no apparently consistent relation of borer injury to progenies. The rat-eaten stalks were found in about equal numbers in puka and trench stools.

In Table 18, is shown the number and percentage of second season and first season stalks for all stools of all progenies in both puka and trench plantings. There was an average of 4.63 second season stalks per stool or 29.68 per cent, in the puka planting as compared with an average of 4.39 stalks per stool, or an average of 29.23 per cent, in the trench planting, practically no difference in the characteristic. However, it will be noticed that the superior yielding progenies usually show a higher percentage of second season stalks than the poor yielding progenies.

In Table 19, is shown the performance record of all outside stools for comparison with that of an equal number of inside stools. The inside stools were in three rows running in a diagonal position across the plot. The average yield of the inside stools was at the rate of 137.16 tons per acre while that of the outside stools was at the rate of 214.04* tons per acre, or about 35 per cent increase in yield due to outside position. The appearance of the stalks in the outside puka stools is illustrated in Fig. 3. The average number of stalks per stool inside the plot was 13.26 as compared with 20.84 outside. The average length of stalks in inside stools was 18 feet as compared with 16.41 outside, indicating a stretching up for light on the part of the inside stalks. The average dead stalks per stool inside was 8.20 per stool while outside it was 6.43 showing the effect of competition in the inside stools. The average number of tasseled stalks per stool inside was 3.61 while outside it was 7.28. The number of tasseled stalks outside was about double that of the inside stalks. The borer-injured stalks inside was 5.93 per stool and 9.29 per stool for the outside stools. The average number of broken stalks per stool inside was 3.62 as compared with 2.58 stalks per stool on the outside. The average quality ratio for the stalks inside was 9.82 as compared with 9.85 for the outside stools. These data indicate that the quality ratio was not affected by the inside or outside position of the stools.

In Table 20, is shown the average quality ratio for puka and trench plantings in each progeny, and the average quality ratio of each progeny. These data indicate that the quality ratio was not seriously affected, as a rule, by the position

of the stools in pukas or in trenches. They also indicate that the superior yielding progenies usually had the best quality ratios while the inferior yielding progenies had the poorer quality ratios. These observations are of fundamental



Fig. 3. Stalks from puka stools showing a group of uniformly large stalks.

significance in that they indicate that the quality ratio is not seriously influenced by certain environmental conditions within the H 109 variety and that the quality ratio is a comparatively stable character which is inherent and capable of improvement through bud selection.

SUMMARY.

The average yield of all of the 126 H 109 stools in this plot was at the rate of 156.12 tons per acre. The figure was calculated from the basis of each stool occupying 25 square feet of area and without any reductions for any cause. It is simply a comparative figure for this study and is not intended to be directly applicable to plantation practices. The average quality ratio for all of the H 109 stools in the plot was 10.05. In this plot the average number of healthy stalks per stool was 15.88 and the average weight per stool was 172.71 pounds. The average number of dead stalks per stool was 6.14, the average number of stalks per stool injured by borer was 7.21, the average number of stalks in each stool found to have been broken or injured mechanically was 3.38 and the average number of tasseled stalks in each stool was 4.46. The average length of the stalks of all stools was 17.95 feet. The average weight of stalks was 10.88 pounds per stalk and the average weight per foot of stalk was .606 pounds.

The average yield of the 83 stools in the puka planting was at the rate of 163.10 tons per acre while the average yield of the 43 stools in the trench planting was at the rate of 144.51 tons per acre. The average quality ratio for the puka stools was 10.32. In the puka stools there was an average of 15.37 healthy stalks per stool while in the trenches the average number of healthy stalks was 16.72. The average weight of stalks in the puka stools was 187.12 pounds while in the trenches this figure was 165.54 pounds. The average number of dead stalks in the puka stools was 4.73 while in the trenches it was 8.47. The average borer damage in the pukas was 6.94 stalks per stool while in the trenches it was 7.64 stalks per stool. The average number of broken stalks in puka stools was 1.98 and in the trench stools it was 5.72. The average number of tasseled stalks in the puka stools was 4.35 while in the trenches it was 4.65 stalks. The average length of stalks in puka stools was 18.33 feet while in the trenches it was 17.33 feet. In the selected comparative puka and trench rows the differences in yield were even more marked than where all of the puka and all of the trench stools were considered.

The average number of dead stalks per stool in the pukas was 4.73 while in the trenches it was 8.47. The sides of the pukas seemed to hold up and protect the stalks somewhat so that there was apparently less competition and struggle for existence in the puka stools than was the case with the trench stools.

Borer damage was about the same in the puka planting as in the trench planting. Broken stalks, largely damage due to windstorms, amounted to an average of only 1.98 stalks per stool in the pukas as compared with an average of 5.72 stalks per stool in the trenches.

The heavy yielding stools were almost invariably composed of uniformly large and heavy stalks, as illustrated in Figs. 4 and 5. The lighter yielding stools were usually made up of stalks which varied greatly in size, weight and other characteristics.

While there was but little difference in the average number of tasseled stalks in puka stools as compared with trench stools, the inside stools were found to have an average of 3.61 tassels per stool as compared with an average of 7.28 tassels per stool on the outside of the plot.

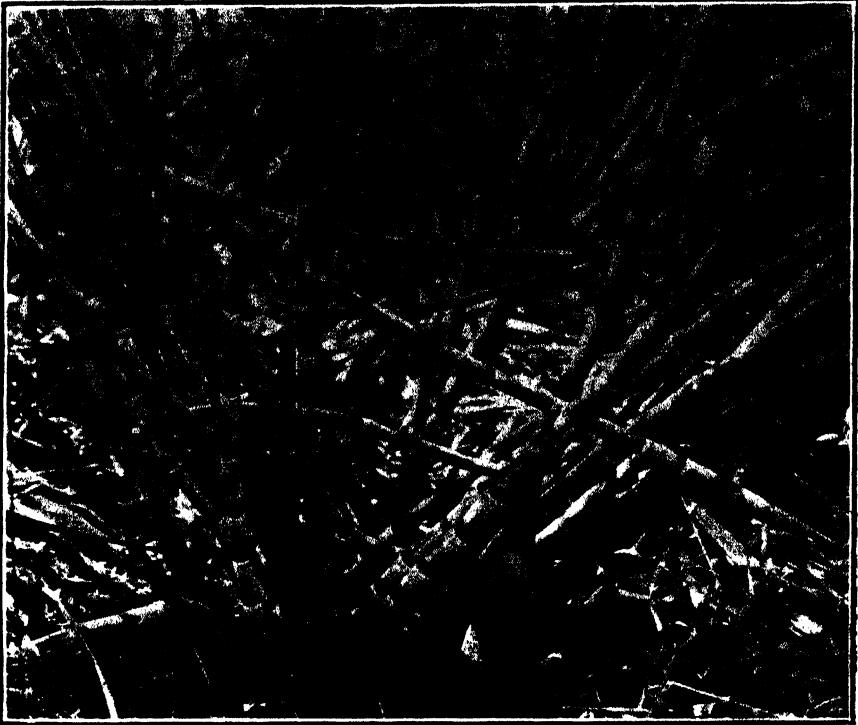


Fig. 4. H 109 stool showing uniformly good stalks.



Fig. 5. H 109 stool showing considerable variation in size of stalks.

The outside stools out-yielded the inside stools at the rate of about 35 per cent in tons per acre, which was largely due to larger and heavier stalks.

The quality ratio did not seem to be affected to any extent by the position, being about the same for inside and outside stools and for puka and trench stools.

The quality ratio was apparently inherent with progenies and with yields, the superior and higher yielding stools and progenies, as a rule, having the higher quality ratio.

High yield and high quality ratio are apparently correlated in this experiment.

The Uba stool, as illustrated in Fig. 6, produced a very high yield of cane and a fair quality ratio. Only a few stalks of Uba were found to be injured by borers and there was only a small number of dead stalks in these stools.

SUGGESTIONS.

Some suggestions arising from a study of this experiment are briefly summarized in the following paragraphs:

Single-eye three-joint cuttings are practicable and their use is important for scientific bud selection studies.

Spaced plantings, the amount of spacing depending upon the soil, climate and other environmental conditions, are fundamentally important in making individual stool studies and in securing definite individual stool and progeny performance record data.

Heavy fertilization, adequate irrigation and the best of cultural conditions are primarily important for this kind of work.

An equal number of stools in each progeny, repeated two or more times if possible, surrounded by a guard row on all sides of the progeny plot is necessary in order to secure accurate comparative stool and progeny performance record data.

A perfect stand is essential and if necessary extra cuttings should be provided for replanting any missing spaces.

A few markedly inferior progenies should be included in every progeny test for comparative purposes and to measure progress.

Systematic observations from the time the cuttings are planted until the plants are harvested are advisable for a full understanding and a correct interpretation of progeny behavior.

The best age for harvesting the plants for performance record study of the H 109 variety seems to be from 12 to 18 months after planting in the progeny field.

The quality ratio is apparently the most stable and therefore one of great interest in bud selection investigation.

Performance records should include individual stool data giving the number of healthy stalks, their weight, the number of dead stalks, the number of stalks attacked by borers or other pests, or diseased stalks, the number of broken stalks or those otherwise damaged, the number of tasseled stalks, the average length of stalks in each stool, the quality ratio of the healthy and uninjured stalks and the number of second season stalks if the crop is carried a second season.

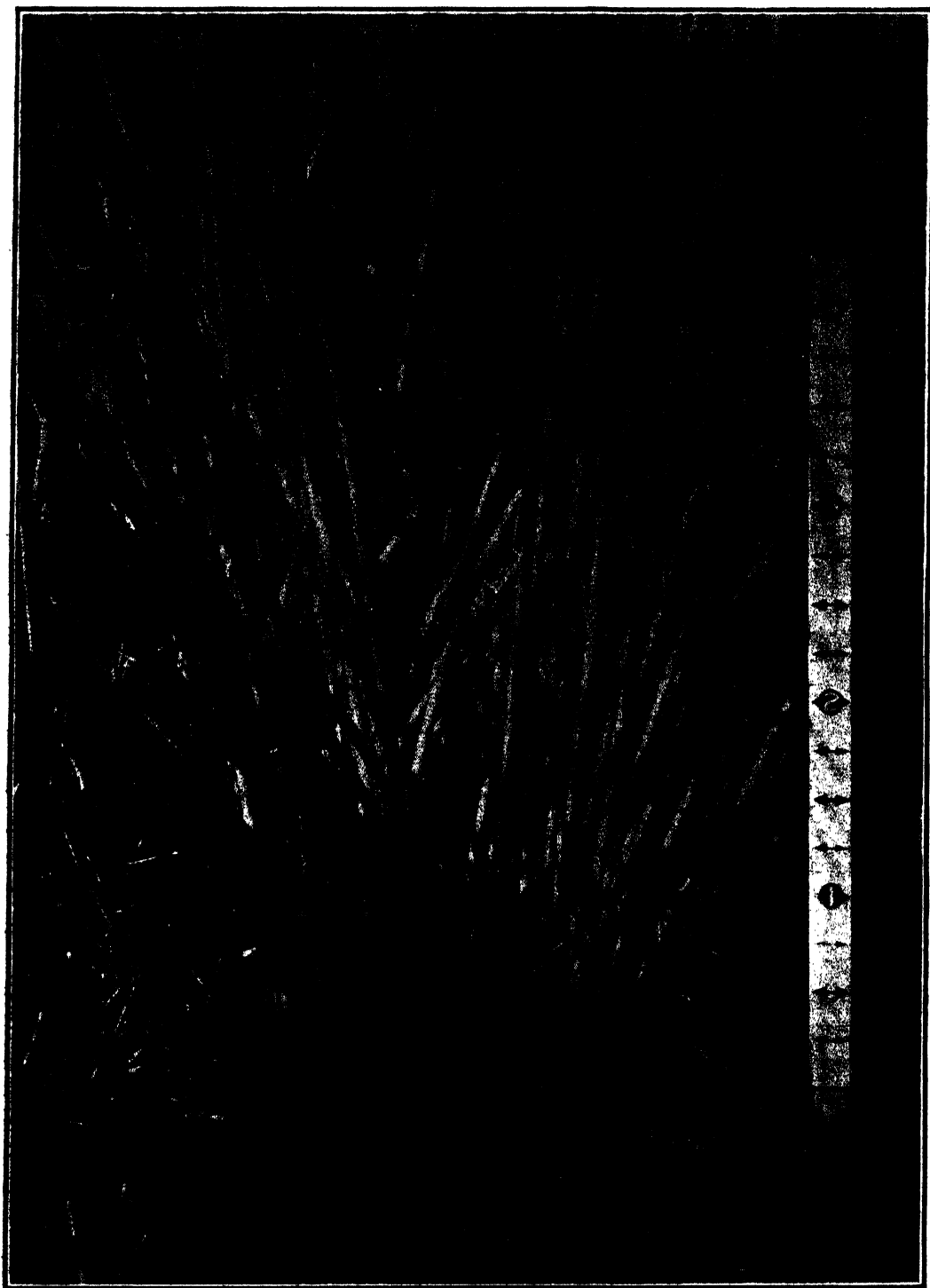


Fig. 6. Uba stool 44-12 after stripping, 144 stalks weighing 334 pounds.

The importance of this work from an economic standpoint seems to be sufficient to justify it as a part of the work of stool and progeny performance record work for the purpose of building up pedigreed plantation plant material through the selection, isolation and propagation of better strains.

TABLE IV.

YIELD OF PROGENY 63, PUKA PLANTING.

Stool No.....	No. of Stalks...	Total Weight...	Total Dead.....	Total Borer.....	Total Mech.....	Total Tassel....	Avg. Length...	Tons per Acre...	Quality Ratio...	Notes.....
49-1	23	288.0	4	12	2	16	16.9	250.91	7.72	very uniform
49-2	18	228.0	2	11	5	8	18.8	198.63		
49-3	16	179.5	4	6	3	2	21.0	156.38		
49-4	21	263.5	3	10	1	4	16.8	229.56	10.34	very uniform
49-5	20	262.0	2	7	..	7	19.2	228.25		
49-6	15	197.0	7	11	..	5	18.2	171.63		
Total.....	113	1418.0	22	57	10	42	110.9	1235.36		
Average ..	18.8	236.6	3.6	9.5	1.6	7.0	18.4	205.89		

YIELD OF PROGENY 63, TRENCH PLANTING.

45-1	25	251.0	6	7	2	10	13.0	218.67		
45-2										20 first season
45-3										shoots taken
										out 1923, on ac-
										count of Yel-
										low Stripe.
45-4	31	415.0	..	6	..	9	16.1	361.55	8.62	very uniform
45-5	25	260.0	2	5	4	4	17.6	226.51		
45-6	20	214.0	..	5	9	6	20.2	186.44		
45-7	26	305.0	2	4	4	8	17.8	265.72	8.77	very uniform
Total.....	127	1445.0	10	27	19	37	84.7	1258.89		
Average ..	25.4	289.0	3.33	5.4	4.75	7.4	16.9	251.78		

TABLE V.

YIELD OF PROGENY S, PUKA PLANTING.

Stool No.....	No. of Stalks...	Total Weight...	Total Dead.....	Total Borer.....	Total Mech.....	Total Tassel....	Avg. Length...	Tons per Acre...	Quality Ratio...	Notes.....
55-4	17	184.0	7	8	3	1	17.8	160.30		
55-5	10	109.5	7	5	3	..	17.0	95.40		
54-4	16	163.5	6	7	2	3	17.2	142.44		
54-5	23	222.0	3	8	6	6	20.0	193.41		
54-6	15	225.0	5	6	6	6	24.0	196.02		
54-7	23	274.0	5	2	..	2	18.5	238.71	10.77	very uniform
54-8	20	267.5	6	10	..	5	16.5	233.04	8.99	very uniform
54-9	36	414.0	5	19	..	11	17.5	360.67	9.89	very uniform
Total.....	161	1859.5	44	65	20	34	147.5	1619.99		
Average ..	20.13	232.44	5.5	8.12	4.0	4.25	18.4	202.49		

TABLE VI.

YIELD OF PROGENY V, PUKA PLANTING.

Stool No.....	No. of Stalks...	Total Weight...	Total Dead.....	Total Borer.....	Total Mech.....	Total Tassel....	Avg. Length...	Tons per Acre...	Quality Ratio...	Notes.....
55-6	13	127.0	9	9	3	1	17.4	110.64		
55-7	20	232.5	13	14	2	2	17.5	202.99		
54-1	22	291.0	6	8	2	4	18.5	253.52	8.53	
54-2	17	236.0	7	7	1	..	19.7	205.60	13.88	
54-3	19	190.0	5	7	1	1	16.4	165.53		
Total.....	91	1076.5	40	45	9	8	89.5	938.28		
Average —	18.2	215.3	8.0	9.0	1.8	2.66	17.9	187.66		

TABLE VII.

YIELD OF PROGENY NO. 142, PUKA PLANTING.

Stool No.....	No. of Stalks...	Total Weight...	Total Dead.....	Total Borer.....	Total Mech.....	Total Tassel....	Avg. Length...	Tons per Acre...	Quality Ratio...	Notes.....
50-1	19	298.0	1	5	2	8	17.8	259.62	8.20	
50-2	15	200.0	3	5	2	4	17.8	174.24		
50-3	13	182.5	2	2	1	3	19.6	158.99		
50-4	14	179.5	1	9	1	5	17.0	156.38		
50-5	16	190.0	..	10	2	4	19.7	165.53		
50-6	24	265.0	2	11	4	5	17.4	230.86		very uniform
50-7	17	236.0	2	4	2	3	16.7	205.60	9.03	uniform
50-8	15	222.5	2	10	..	6	18.6	193.84	10.47	uniform
Total.....	133	1773.5	14	56	14	38	144.6	1545.06		
Average ..	16.6	221.7	2	7	2	4.75	18.1	193.13		

YIELD OF PROGENY NO. 142, TRENCH PLANTING.

47-1	19	219.5	10	10	4	7	16.6	191.23
47-2	4	22.0	15	1	3	..	14.2	19.17
47-3	10	105.5	10	3	3	1	18.4	91.91
47-4	4	16.0	16	..	4	..	10.0	13.94
47-5	5	63.0	13	2	4	2	18.0	54.89
47-6	4	30.0	16	4	3	..	19.0	26.14
46-1	18	257.5	5	6	1	9	14.4	224.33
46-2	12	142.0	14	3	2	4	18.0	123.71
46-3	11	126.5	13	1	2	1	16.4	110.21
46-4	11	136.5	15	3	3	8	21.0	118.92

Stool No.....	No. of Stalks...	Total Weight...	Total Dead.....	Total Borer.....	Total Meech.....	Total Tassel.....	Avg. Length....	Tons per Acre...	Quality Ratio...	Notes.....
46-5	5	61.0	16	1	2	3	16.4	53.14		
46-6	5	58.5	12	..	2	2	21.6	50.97		
46-7	13	72.0	14	12	7	..	14.3	62.73		
46-8	8	63.5	15	2	3	..	14.5	55.32		
46-9	11	94.5	6	9	..	4	19.6	82.33		
46-10	11	153.5	4	11	3	6	20.9	133.73	11.93	
46-11	34	265.5	8	15	3	11	10.6	231.96	8.65	
45-11	16	233.0	2	11	1	14	22.0	202.77	9.29	
45-12	15	172.5	4	4	3	..	16.4	150.28	8.94	
Total.....	218	2292.5	208	98	53	72	322.3	1997.68		
Average ..	11.5	120.66	10.95	5.77	2.95	5.54	16.96	105.14		

TABLE VIII.

YIELD OF PROGENY NO. 48, PUKA PLANTING.

Stool No.....	No. of Stalks...	Total Weight...	Total Dead.....	Total Borer.....	Total Meech.....	Total Tassel.....	Avg. Length....	Tons per Acre...	Quality Ratio...	Notes.....
57-1	21	315.0	5	11	1	10	18.4	274.42	8.99	very uniform
57-2	17	237.5	4	8	2	1	17.5	206.91		
57-3	12	166.5	12	6	2	1	19.5	145.05		
57-4	17	212.0	4	8	3	6	17.2	184.69		
57-5	15	202.0	7	4	2	5	17.8	175.98		
57-6	13	192.5	10	6	2	8	16.8	167.71		
57-7	13	174.5	11	5	3	3	16.9	152.02		
56-1	23	310.5	3	14	6	13	15.8	270.51	10.93	
56-2	11	135.0	1	9	3	1	15.4	117.61		
56-3	14	178.0	6	8	2	6	16.0	155.07		
56-4	10	120.0	8	3	2	4	16.8	104.54		
56-5	7	89.5	10	6	2	1	17.7	77.97		
56-6	26	283.5	5	16	4	5	17.3	246.99	10.25	very uniform stalks
56-7	11	155.0	7	7	2	5	16.2	135.04		
56-8	19	223.0	10	11	3	4	16.3	194.28		
55-1	23	293.5	5	10	2	7	16.1	255.70	9.77	
55-2										missing
55-3	13	147.0	6	7	2	1	18.2	128.07		
55-8	19	212.0	1	7	..	..	17.1	184.69	10.86	
55-9	26	262.5	12	12	..	..	15.4	228.69		
Total.....	310	3909.5	127	158	43	81	322.4	3405.94		
Average ..	16.32	205.77	6.68	8.32	2.53	4.77	16.96	179.26		

TABLE IX.
YIELD OF PROGENY NO. 94, PUKA PLANTING.

Stool No.....	No. of Stalks...	Total Weight...	Total Dead.....	Total Borer.....	Total Mech.....	Total Tassel....	Avg. Length...	Tons per Acre...	Quality Ratio...	Notes.....
53-7	2	17.5	6	1	1	..	24.0	15.25		
53-8	3	33.0	3	2	1	..	18.0	28.75		
53-9	5	72.5	3	1	..	..	22.0	63.16		
53-10	26	277.5	..	7	1	2	15.4	241.75	10.19	
49-7	15	163.0	3	10	5	2	20.3	142.01		
49-8	14	169.5	6	10	3	1	17.0	147.67		
49-9	21	249.0	3	6	..	4	16.7	216.93	9.33 uniform	
49-10	22	278.0	6	13	1	5	15.6	242.19	11.54	
49-11	33	319.0	11	14	..	16	15.7	277.91	9.08 uniform	
Total.....	141	1579.0	41	64	11	30	164.7	1375.62		
Average ..	15.7	174.3	4.7	7.0	2.2	5.0	18.5	152.85		

YIELD OF PROGENY NO. 94, TRENCH PLANTING.										
45-8	35	276.5	3	4	11	4	13.0	240.89		
45-9	19	177.0	6	11	..	4	16.5	154.20		
45-10	11	146.0	5	11	5	..	20.0	127.20		
Total.....	65	599.5	14	26	16	8	49.5	522.29		
Average ..	21.7	199.8	4.7	8.7	8.0	4.0	16.5	174.09		

TABLE X.

Stool No.....	No. of Stalks...	Total Weight...	Total Dead.....	Total Borer.....	Total Mech.....	Total Tassel....	Avg. Length...	Tons per Acre...	Quality Ratio...	Notes.....
51-4	12	161.5	3	9	1	5	21.7	140.70		
51-5	10	114.5	5	3	1	2	17.8	99.75		
51-6	17	194.0	3	9	..	5	18.0	169.01		
51-7	9	148.0	3	3	..	6	20.0	128.94		
51-8	13	211.0	2	2	..	7	19.3	183.82	9.37 fairly uniform	
Total.....	61	829.0	16	26	2	25	96.8	722.32		
Average ..	12.2	165.8	3.2	5.2	1.0	5.0	19.4	144.46		

YIELD OF PROGENY NO. 154, TRENCH PLANTING.										
47-7	9	99.5	10	3	9	1	20.0	86.68		
47-8	10	54.5	11	10	10	..	20.0	47.48		
47-9	15	131.5	3	14	13	5	19.6	114.56		
Total.....	34	285.5	24	27	32	6	59.6	248.72		
Average ..	11.33	93.17	8.0	9.0	10.7	3.0	19.9	82.91		

TABLE XI.

YIELD OF PROGENY NO. 155, PUKA PLANTING.

Stool No.....	No. of Stalks...	Total Weight...	Total Dead.....	Total Borer.....	Total Tassel.....	Total Mech.....	Avg. Length...	Tons per Acre...	Quality Ratio...	Notes.....
52-1	19	300.0	1	5	1	9	18.4	261.36		
52-2	6	58.5	10	3	..	..	21.0	50.97		
52-3	13	163.5	6	8	2	3	20.0	142.44		
52-4	6	65.0	4	2	1	..	18.8	56.63		
52-5	11	144.0	4	5	2	2	19.1	125.45		
52-6	12	124.0	4	4	..	3	21.0	108.03		
52-7	12	148.0	3	5	1	6	18.0	128.94		
52-8	14	172.5	5	7	1	4	21.1	150.28		
52-9	15	178.0	1	10	..	4	17.3	155.07	11.80	
51-9	17	191.0	6	10	..	1	17.8	166.40		
51-10	22	239.0	4	10	..	7	16.5	208.22	14.29	
Total.....	147	1783.5	48	69	8	39	209.0	1553.79		
Average ..	13.36	162.14	4.36	6.27	1.33	4.33	19.0	141.25		

YIELD OF PROGENY NO. 155, TRENCH PLANTING.

48-1	17	206.5	7	12	2	5	17.6	179.90		
48-2	11	73.0	12	6	3	1	16.5	63.60		
48-3	14	151.5	8	7	..	3	19.7	131.99		
48-4	13	146.0	12	7	2	5	17.0	127.20		
48-5	3	26.5	17	1	1	..	18.7	23.09		
48-6	14	95.0	13	7	7	1	19.6	82.76		
48-7	13	120.0	11	7	8	1	18.0	104.54		
47-10	11	108.0	10	9	1	3	14.8	94.08	13.60	
Total.....	96	926.5	90	56	24	19	141.9	807.17		
Average ..	12.0	115.81	11.25	7.00	3.42	2.71	17.73	100.89		

TABLE XII.

YIELD OF PROGENY NO. 156, PUKA PLANTING.

Stool No.....	No. of Stalks...	Total Weight...	Total Dead.....	Total Borer.....	Total Tassel.....	Total Mech.....	Avg. Length...	Tons per Acre...	Quality Ratio...	Notes.....
53-1	10	112.5	9	6	2	1	18.2	98.01		
53-2	4	40.5	7	1	1	..	18.0	35.28		
53-3	9	109.0	2	4	3	3	16.5	94.96		
53-4	7	74.0	5	4	3	1	21.0	64.47		
53-5	6	90.5	3	..	..	3	18.9	78.84		
53-6	6	78.0	3	2	..	1	19.0	67.95		
52-10	24	248.0	4	11	2	9	15.9	216.06	11.10	
Total.....	66	752.5	33	28	11	18	127.5	655.57		
Average ..	9.4	107.5	4.7	4.0	1.5	2.5	18.2	93.65		

YIELD OF PROGENY NO. 156, TRENCH PLANTING.

Stool No.....	No. of Stalks.....	Total Weight...	Total Dead.....	Total Borer.....	Total Mech.....	Total Tassel.....	Avg. Length.....	Tons per Acre...	Quality Ratio...	Notes.....
48-8	10	125.5	10	7	5	1	14.0	109.34		
48-9	12	83.5	10	9	11	..	22.5	72.75		
48-10	20	210.0	6	12	1	2	16.5	182.95	14.63	
48-11	21	180.0	10	13	..	2	14.5	156.82	13.40	
47-11	31	275.0	7	19	1	16	12.6	239.58		tassel
Total.....	94	874.0	63	50	18	21	80.1	761.44		
Average ..	18.50	174.8	12.6	10.0	4.5	5.25	16.02	152.29		

TABLE XIII.

YIELD OF PROGENY NO. 153, PUKA PLANTING.

Stool No.....	No. of Stalks.....	Total Weight...	Total Dead.....	Total Borer.....	Total Mech.....	Total Tassel.....	Avg. Length...	Tons per Acre...	Quality Ratio...	Notes.....
51-1	17	223.5	4	3	3	5	18.1	194.71		
51-2	11	107.5	6	4	4	3	19.0	93.65		
51-3	4	39.5	7	1	1	..	20.0	34.41		
50-9	17	189.5	2	10	..	3	18.4	165.09	11.99	
50-10	16	188.0	4	7	1	5	16.3	163.79	11.36	
Total.....	65	748.0	23	25	9	16	91.8	651.65		
Average ..	13.0	149.6	4.6	5.0	1.8	3.2	18.4	130.33		

YIELD OF OUTSIDE ROW, EAST SIDE, PUKA PLANTING, LYMAN SEEDLING.

44-1	8	79.0	4	8	1	2	10.9	68.82	7.05	
Progeny No. 142.										
44-2	16	149.0	..	11	..	4	14.9	129.81		
44-3	19	159.5	..	10	..	7	13.8	138.96		
44-4	24	189.5	2	11	2	8	12.2	165.09		
44-5	19	177.5	2	4	2	5	13.3	154.64		
Total.....	68	675.5	4	36	4	24	54.2	588.50		
Average ..	17.0	168.9	2.0	9.0	2.0	6.0	13.6	147.13		
Progeny No. 155										
44-6	21	193.5	..	5	2	8	15.3	168.58	9.52	
44-7	13	123.5	..	5	1	3	13.9	107.59		
Total.....	34	317.0	..	10	3	11	29.2	276.17		
Average ..	17.0	158.5	..	5.0	1.5	5.5	14.6	138.09		
Progeny No. 63.										
44-8	8	72.0	..	5	..	3	16.7	62.73		

Stool No.	No. of Stalks...	Total Weight...	Total Dead.....	Total Borer.....	Total Tassel....	Total Mech.....	Avg. Length.....	Tons per Acre...	Quality Ratio...	Notes.....
44-9	101	299.5	12	6	6	1	10.0	260.92	10.53	
44-10	95	233.5	6	3	9	..	9.0	203.43	10.11	
44-11	92	215.0	8	2	..	..	10.0	187.31	11.56	
45-12	144	334.0	7	..	..	..	11.0	290.98	9.85	
Total.....	432	1082.0	33	11	15	1	40.0	942.64		
Average ..	108	270.5	8.3	3.7	7.5	1.0	10.0	235.66		

TABLE XIV.

COMPARATIVE PROGENY YIELDS PER ACRE EXPRESSED IN PERCENTAGES ABOVE OR BELOW THE AVERAGE.

Puka Planting.

Average yield 163.10 T. P. A. = 100%.

No. of Stools	Progeny	Percentage Above		
		or Below 100	Plus	Minus
19	48	109.91	9.91	.....
9	8	124.15	24.15	.....
5	5	115.06	15.06	.....
7	156	57.42	.....	42.48
5	153	79.91	.....	20.09
9	94	93.72	.....	6.28
11	155	86.60	.....	13.40
5	154	88.57	.....	11.43
8	142	118.41	18.41	.....
6	63	126.24	26.24	.....

Trench Planting.

Average yield 144.51 T. P. A. = 100%.

4	94	120.47	20.47	.....
8	155	68.81	.....	31.12
3	154	57.37	.....	42.63
19	142	72.76	.....	27.24
5	63	174.23	74.23	.....
5	156	105.38	5.38	.....

TABLE XV.

COMPARATIVE YIELDS OF PUKA AND TRENCH PLANTINGS TWO ROWS OF EACH.

Puka Planting.

Stool No.	No. of Stalks	Total Weight	Total Dead	Total Borer	Total Mech.	Total Tassel	Avg. Weight	Tons per Acre	Progeny No.
51-1	17	223.5	4	3	3	5	18.1	194.71	153
51-2	11	107.5	6	4	4	3	19.0	93.65	153
51-3	4	39.5	7	1	1	..	20.0	34.41	153

Stool No.	No. of Stalks	Total Weight	Total Dead	Total Borer	Total Mech.	Total Tassel	Avg. Weight	Tons per Acre	Progeny No.
51-4	12	161.5	3	9	1	5	21.7	140.70	154
51-5	10	114.5	5	3	1	2	17.8	99.75	154
51-6	17	194.0	3	9	..	5	18.0	169.01	154
51-7	9	148.0	3	3	..	6	20.0	128.94	154
51-8	13	211.0	2	2	..	7	19.3	183.82	154
51-9	17	191.0	6	10	..	1	17.8	166.40	155
51-10	22	239.0	4	10	..	7	16.5	208.22	155
50-1	19	298.0	1	5	2	8	17.8	259.62	142
50-2	15	200.0	3	5	2	4	17.8	174.24	142
50-3	13	182.5	2	2	1	3	19.6	158.99	142
50-4	14	179.5	1	9	1	5	17.0	156.38	142
50-5	16	190.0	..	10	2	4	19.7	165.53	142
50-6	24	265.0	2	11	4	5	17.4	230.86	142
50-7	17	236.0	2	4	2	3	16.7	205.60	142
50-8	15	222.5	2	10	..	6	18.6	193.84	142
50-9	17	189.5	2	10	..	3	18.4	165.09	153
50-10	16	188.0	4	7	1	5	16.3	163.79	153
<hr/>									
Total	298	3780.5	62	127	25	87	367.5	3293.55	
Average ..	14.9	189.03	3.26	6.35	1.92	4.58	18.38	164.68	

Trench Planting.

47-1	19	219.5	10	10	4	7	16.6	191.23	142
47-2	4	22.0	15	1	3	..	14.2	19.17	142
47-3	10	105.5	10	3	3	1	18.4	91.91	142
47-4	4	16.0	16	..	4	..	10.0	13.94	142
47-5	5	63.0	13	2	4	2	18.0	54.89	142
47-6	4	30.0	16	4	3	..	19.0	26.14	142
47-7	9	99.5	10	3	9	1	20.0	86.68	154
47-8	10	54.5	11	10	10	..	20.0	47.48	154
47-9	15	131.5	3	14	13	5	19.6	114.56	154
47-10	11	108.0	10	9	1	3	14.8	94.09	155
47-11	31	275.0	7	19	1	16	12.6	239.58	156
46-1	18	257.5	5	6	1	9	14.4	224.33	142
46-2	12	142.0	14	3	2	4	18.0	123.71	
46-3	11	126.5	13	1	2	1	16.4	110.21	
46-4	11	136.5	15	3	3	8	21.0	118.92	
46-5	5	61.0	16	1	2	3	16.4	53.14	
46-6	5	58.5	12	..	2	2	21.6	50.97	
46-7	13	72.0	14	12	7	..	14.3	62.73	
46-8	8	63.5	15	2	3	..	14.5	55.32	
46-9	11	94.5	6	9	..	4	19.6	82.33	
46-10	11	153.5	4	11	3	6	20.9	133.73	
46-11	34	265.5	8	15	3	11	10.6	231.96	
<hr/>									
Total	261	2555.50	243	138	84	83	370.9	2227.02	
Average ..	11.86	116.16	11.05	6.90	4.00	5.19	16.86	101.23	

TABLE XVI.

COMPARATIVE DEAD STALK DATA IN DIFFERENT PROGENIES.

Puka Planting.

No. of Stools	Progeny	No.	No. Stalks	No. Stalks	Total	Per Cent Dead	Total	Average
			Living	Dead			Plus	Minus
19	48		16.32	6.68	23.00	29.04	5.46	.....
8	S		20.13	5.50	25.63	21.46	....	2.12
5	V		18.20	8.00	26.20	30.53	7.05	.....
7	156		9.40	4.70	14.10	33.33	9.75	.....
5	153		13.00	4.60	17.60	26.15	2.57	.....
9	94		15.70	4.70	20.40	23.04	....	.54
11	155		13.36	4.36	17.72	24.60	1.02	.....
5	154		12.20	3.20	15.40	20.78	....	2.80
8	142		16.60	2.00	18.60	10.75	....	12.83
6	63		18.80	3.60	22.40	16.07	....	7.51
Total						235.75		

Trench Planting.

4	155	12.00	11.25	23.25	48.39	13.61	.....
8	154	11.33	8.00	19.33	41.39	6.61	.....
3	142	11.40	10.95	22.35	48.99	14.21	.....
19	63	25.40	3.33	28.73	11.59	.....	23.19
5	156	18.50	12.60	31.10	40.51	5.73	.....
5	94	21.70	4.70	26.40	17.80	.....	16.98
Total					208.67		
Average					34.78		
Average for Puka and Trench Stools.....					27.78		

TABLE XVII.

COMPARATIVE BORER DAMAGE IN PROGENIES.

Puka Plantings.

No. of Stools	Progeny	Total Stalks	Borer Stalks	Progenies		
				Per Cent Borer	Most Damage	Least Damage
19	48	23.00	8.32	36.17	1.92	....
8	S	25.63	8.12	31.68	....	2.57
5	V	26.20	9.00	34.35	.10	....
7	156	14.10	4.00	28.37	....	5.88
5	153	17.60	5.00	28.41	....	5.84
9	94	20.40	7.00	34.31	.06	....
11	155	17.72	6.27	35.38	1.13	....
5	154	15.40	5.20	33.77	....	.48
8	142	18.60	7.00	37.63	3.38	....
6	63	22.40	9.50	42.41	8.16	....
Total				342.48		
Average Puka				34.25		

Trench Plantings.

No. of Stools	Progeny	Total Stalks	Borer Stalks	Progenies		
				Per Cent	Most Damage	Least Damage
				Borer	Plus	Minus
4	94	26.40	8.70	32.96	1.91	....
8	155	23.25	7.00	30.11	....	.94
3	154	19.33	9.00	46.56	15.51	....
19	142	22.35	5.77	25.82	....	5.23
5	63	28.73	5.40	18.80	....	12.25
5	156	31.10	10.00	32.16	1.11	....
Total				186.41		
Average Trench				31.07		
Average for all Puka and Trench Stools... .				33.06		

TABLE XVIII.

COMPARATIVE SECOND AND FIRST SEASON STALK DEVELOPMENT IN PROGENIES.

Puka Planting.

Progeny	Total No.	No. of 2nd	Per Cent 2nd	No. of 1st	Per Cent 1st	Kind of
No.	of Stalks	Season Stalks	Season Stalks	Season Stalks	Season Stalks	Planting
94	15.67	7.11	45.37	8.56	54.63	Puka
63	18.85	4.33	22.97	14.50	77.03	"
S	20.00	6.87	34.35	13.13	65.65	"
V	18.50	5.00	27.03	13.50	72.97	"
142	16.63	4.75	28.56	11.88	71.44	"
48	16.32	7.32	44.85	9.00	55.15	"
154	12.20	1.80	14.75	10.40	85.25	"
153	13.00	3.00	23.08	10.00	76.92	"
155	13.36	2.80	20.96	10.56	79.04	"
156	9.43	3.29	34.89	6.14	65.11	"
Total	153.96	46.27	296.81	107.67	703.19	"
Average..	15.40	4.63	29.68	10.77	70.32	"

Trench Planting.

94	18.83	3.33	18.17	15.00	81.83	Trench
63	25.40	7.40	29.13	18.00	70.87	"
142	11.50	2.87	24.96	8.63	75.04	"
154	11.33	.33	29.13	11.00	70.87	"
155	12.00	2.62	21.83	9.38	78.17	"
156	18.80	9.80	52.13	9.00	47.67	"
Total	97.86	26.35	175.35	71.01	424.45	"
Average..	16.31	4.39	29.23	11.84	70.74	"

TABLE XIX.

COMPARATIVE BEHAVIOR OF INSIDE AND OUTSIDE STOOLS.

Inside Stools.

Progeny	Stool No.	T. P. A.	Weight in Lbs.	No. Stalks	Length Stalk	Dead	Tassel	Borer	Mech.	Q.R.
142	46-2	123.71	142.00	12.00	18.00	14.00	4.00	3.00	2.00	....
155	48-4	127.20	146.00	13.00	17.00	12.00	5.00	7.00	2.00	....
142	47-3	91.91	105.50	10.00	18.40	10.00	1.00	3.00	3.00	....
63	49-5	228.25	262.00	20.00	19.20	2.00	7.00	7.00	....	....
142	50-6	230.86	265.00	24.00	17.40	2.00	5.00	11.00	4.00	....
154	51-7	128.94	148.00	9.00	20.00	3.00	6.00	3.00	....	....
155	52-8	150.28	172.50	14.00	21.10	5.00	4.00	7.00	1.00	....
142	46-3	110.21	126.50	11.00	16.40	13.00	1.00	1.00	2.00	....
142	47-4	13.94	16.00	4.00	10.00	16.00	....	....	4.00	....
155	48-5	23.09	26.50	3.00	18.70	17.00	....	1.00	1.00	....
63	49-6	171.63	197.00	15.00	18.20	7.00	5.00	12.00	....	....
142	50-7	205.60	236.00	17.00	16.70	2.00	3.00	4.00	2.00	9.03
154	51-8	183.82	211.00	13.00	19.30	2.00	7.00	2.00	....	9.37
155	52-9	155.07	178.00	15.00	17.30	1.00	4.00	10.00	....	11.80
142	46-4	118.92	136.50	11.00	21.00	15.00	8.00	3.00	3.00	....
142	47-5	54.89	63.00	5.00	18.00	13.00	2.00	2.00	4.00	....
155	48-6	82.76	95.00	14.00	19.60	13.00	1.00	7.00	7.00	....
94	49-7	142.01	163.00	15.00	20.30	3.00	2.00	10.00	5.00	....
142	50-8	193.84	222.50	15.00	18.60	2.00	6.00	10.00	....	10.47
155	51-9	166.40	191.00	17.00	17.80	6.00	1.00	10.00	....	...
63	45-4	361.55	415.00	31.00	16.10	....	9.00	6.00	....	8.62
142	46-5	53.14	61.00	5.00	16.40	16.00	3.00	1.00	2.00	....
142	47-6	26.14	30.00	4.00	19.00	16.00	....	4.00	3.00	....
155	48-7	104.54	120.00	13.00	18.00	11.00	1.00	7.00	8.00	....
94	49-8	147.67	169.50	14.00	17.00	6.00	1.00	10.00	3.00	....
153	50-9	165.09	189.50	17.00	18.40	2.00	3.00	10.00	....	11.99
63	45-5	226.51	260.00	25.00	17.60	2.00	4.00	5.00	4.00	....
142	46-6	50.97	58.50	5.00	21.60	12.00	2.00	....	2.00	....
154	47-7	86.68	99.50	9.00	20.00	10.00	1.00	3.00	9.00	....
156	48-8	109.34	125.50	10.00	14.00	10.00	1.00	7.00	5.00	....
94	49-9	216.93	249.00	21.00	16.90	3.00	4.00	6.00	....	9.33
Total		4251.89	4775.00	411.00	558.00	246.00	101.00	172.00	76.00	
Average		137.16	154.03	13.26	18.00	8.20	3.61	5.93	3.62	9.82

Outside Stools.

Progeny	Stool No.	T. P. A.	Weight in Lbs.	No. Stalks	Length Stalk	Dead	Tassel	Borer	Mech.	Q.R.
63	45-1	218.67	251.00	25.00	13.00	6.00	10.00	7.00	2.00	....
142	46-1	224.33	257.50	18.00	14.40	5.00	9.00	6.00	1.00	....
142	47-1	191.23	219.50	19.00	16.60	10.00	7.00	10.00	4.00	....
155	48-1	179.90	206.50	17.00	17.60	7.00	5.00	12.00	2.00	....
63	49-1	250.91	288.00	23.00	16.90	4.00	16.00	12.00	2.00	7.72
142	50-1	259.62	298.00	19.00	17.80	1.00	8.00	5.00	8.00	8.20
153	51-1	194.71	223.50	17.00	18.10	4.00	5.00	3.00	3.00	....
155	52-1	261.36	300.00	19.00	18.40	1.00	9.00	5.00	1.00	....
156	53-1	98.01	112.50	10.00	18.20	9.00	1.00	6.00	2.00	....
V	54-1	253.52	291.00	22.00	18.50	6.00	4.00	8.00	4.00	8.53
48	55-1	255.70	293.50	23.00	16.10	5.00	7.00	10.00	2.00	9.11
48	56-1	270.51	310.50	23.00	15.80	3.00	13.00	14.00	6.00	10.93
48	57-1	274.42	315.00	21.00	18.40	5.00	10.00	11.00	1.00	8.91
48	57-2	206.91	237.50	17.00	17.50	4.00	1.00	8.00	2.00	....
48	57-3	145.05	166.50	12.00	19.50	12.00	1.00	6.00	2.00	....
48	57-4	184.69	212.00	17.00	17.20	4.00	6.00	8.00	3.00	....
48	57-5	175.98	202.00	15.00	17.80	7.00	5.00	4.00	2.00	....
48	57-6	167.71	192.50	13.00	16.80	10.00	8.00	6.00	2.00	....
48	57-7	152.02	174.60	13.00	16.90	11.00	3.00	5.00	3.00	....
48	56-8	194.28	223.00	19.00	16.30	10.00	4.00	11.00	3.00	....
48	55-9	228.69	262.50	26.00	15.40	12.00	....	12.00	....	....
S	54-9	360.67	414.00	36.00	17.50	5.00	11.00	19.00	....	9.89
94	53-10	241.75	277.50	26.00	15.40	....	2.00	7.00	2.00	10.19
156	52-10	216.06	248.00	24.00	15.90	4.00	9.00	11.00	2.00	11.10
155	51-10	208.22	239.00	22.00	16.50	4.00	7.00	10.00	....	14.29
153	50-10	163.79	188.00	16.00	16.30	4.00	5.00	7.00	1.00	11.36
94	49-11	277.91	319.00	33.00	15.70	11.00	16.00	14.00	....	9.08
156	48-11	156.82	180.00	21.00	14.50	10.00	2.00	13.00	....	13.40
156	47-11	239.58	275.00	31.00	12.60	7.00	16.00	19.00	1.00	....
142	46-11	231.96	265.50	34.00	10.60	8.00	11.00	15.00	3.00	8.65
142	45-12	150.28	172.50	15.00	16.40	4.00	....	4.00	3.00	8.94
Total		6635.21	7615.10	646.00	508.60	193.00	211.00	288.00	67.00	
Average		214.04	245.65	20.84	16.41	6.43	7.28	9.29	2.58	9.85

TABLE XX.

COMPARATIVE PROGENY AVERAGE QUALITY RATIOS.

	Progeny	Stool	Weight	Q. R.	Wt. \times Q. R.	Ave. Q. R.	
Trench ...	63	45-4	415.00	8.62	3577.30		
" ...	63	45-7	305.00	8.77	2674.85		
			<hr/>		<hr/>		
			715.00	\div	6252.15 =	8.74	} = 8.84 Avg. Q. R. Prog. 63
Puka	63	49-1	288.00	7.72	2223.36		
"	63	49-4	263.50	10.34	2724.59		
			<hr/>		<hr/>		
			551.50	\div	4947.95 =	8.91	
Puka	8	54-7	274.00	10.77	2950.98		
"	8	54-8	267.50	8.99	2404.83		
"	8	54-9	414.00	9.89	4094.46		
			<hr/>		<hr/>		
			955.50	\div	9450.27 =	9.89	
Puka	V	54-1	291.00	8.53	2482.23		
"	V	54-2	236.00	13.88	3275.68		
			<hr/>		<hr/>		
			527.00	\div	5757.91 =	10.93	
Trench ...	142	46-10	153.50	11.93	1831.26		
" ...	142	46-11	265.50	8.65	2296.58		
" ...	142	45-11	233.00	9.29	2164.57		
" ...	142	45-12	172.50	8.94	1542.15		
			<hr/>		<hr/>		
			824.50	\div	7834.56 =	9.50	} = 9.58 Avg. Q. R. Prog. 142
Puka	142	50-7	236.00	9.03	2131.08		
"	142	50-8	222.50	10.47	2329.58		
			<hr/>		<hr/>		
			458.50	\div	4160.66 =	9.73	
Trench ...	48	55-8	212.00	10.86	2302.32 =	10.86	} = 10.20 Avg. Q. R. Prog. 48
Puka	48	57-1	315.00	8.99	2831.85		
"	48	56-1	310.50	10.93	3393.77		
"	48	56-6	283.50	10.25	2905.87		
"	48	55-1	293.50	9.77	2867.50		
			<hr/>		<hr/>		
			1414.50	\div	14301.31 =	10.11	
Puka	94	53-10	277.50	10.19	2827.73		
"	94	49-9	249.00	9.33	2323.17		
"	94	49-10	278.00	11.54	3208.12		
"	94	49-11	319.00	9.08	2896.52		
			<hr/>		<hr/>		
			1123.50	\div	11255.54 =	10.02	
Puka	154	51-8	211.00	9.37	1977.07 =	9.37	
Trench ...	155	47-10	108.00	13.60	1468.80 =	13.60	} = 13.30 Avg. Q. R. Prog. 155
Puka	155	52-9	178.00	11.80	2100.40		
"	155	51-10	239.00	14.29	3415.31		
			<hr/>		<hr/>		
			417.00	\div	5515.71 =	13.23	

	Progeny	Stool	Weight	Q. R.	Wt. × Q. R.	Ave. Q. R.	
Trench ...	156	48-10	210.00	14.63	3072.30		
" ...	156	48-11	180.00	13.40	2412.00		
			390.00	÷	5484.30 =	14.06	} = 12.91 Avg. Q. R. Prog. 156 "
Puka	156	52-10	248.00	11.10	2752.80 =	11.10	
Puka	153	50-9	189.50	11.99	2272.11		
"	153	50-10	188.00	11.36	2135.68		
			377.50	÷	4407.79 =	11.68	
Grand Average Q. R.							
Trench ...			2249.50		20930.13 =	9.30	
Puka			6284.00		64827.01 =	10.32	
All			8533.50		85757.14 =	10.05	

The above described test was originally suggested by published information from the Cuban Experiment Station wherein enormous yields were reported from widely spaced sugar cane plants. The plants were grown from single eyes which remained upon three-joint cuttings after destroying the other buds. The cuttings were started in small flats or boxes and afterwards planted in holes about 20 inches deep. These holes were gradually filled with stable manure and adequate irrigation supplied, so that the plants at no time lacked water.

In our work, the method reported by the Cuban Station was followed and in addition 100 pounds of nitrogen per month were added for sixteen months, making 1,600 pounds of nitrogen in all. This extremely high fertilization was checked by pot experiments in which double this application showed no visible injury to the cane. In the summer months as much as 8 inches of water a week was applied.

The experiment was one in forced cropping and since selected progenies were used, the opportunity of studying the behavior of the different progenies was followed by A. D. Shamel, who harvested the cane and took weights and measurements. Apart from the bud selection data, this little plot of cane offers some rather interesting information:

1. Notwithstanding the wide spacing, 5 feet apart each way, the factor which finally checked yields more than anything else seemed to be overcrowding.

2. It was very apparent from the condition of this cane at the time of harvest that had it been harvested a few months earlier the yield would have been greater, as the growth which had taken place in the last few months was more than counterbalanced by dead cane. This has strengthened our belief that the two-year cropping period is not an efficient use of time, and that there is much to be gained by studying the possibilities of the shorter periods which would give two crops in three years or thereabouts.

Preservation of Railroad Ties*

The American Wood Preservers' Association consists of representatives of the leading railways in the United States, and representatives of lumbering firms and creosoting plants. Railways which are represented are such as the Atcheson

* Review of the Report of the Committee on Treatment of Railway Ties of the American Wood-Preservers' Association, 1923.

Topeka and Santa Fe, Southern Pacific, New York Central, Pennsylvania, Baltimore and Ohio. The representatives are usually engineers or purchasing agents.

These railways have found that a large part of the maintenance costs of railways consists in tie replacements and the labor involved in such replacements. Working to reduce the costs of these replacements it has been found in years gone by that treatment of the ties with preservatives results in greatly increased length of service; in many cases the length of service of treated ties has been 50 and sometimes 100 per cent greater than untreated ties of the same character. There has resulted from this a somewhat specialized branch of engineering dealing entirely with the preservation of railway ties.

The success of these tie treatments has led to the use of wood preservatives in many other lines of construction. Bridge timbers, marine piles, farm structures, flumes and in fact all sorts of wooden construction exposed to conditions favorable to deterioration are now profitably treated with wood preservatives.

This development has occurred in the United States where temperature and rainfall conditions are temperate; in the tropics, as in this country, wood deterioration is much more rapid due to higher temperatures and more humidity. It would be expected, therefore, that treatment with wood preservatives for railway ties, plantation buildings, fence posts, flumes and flume supports would result in even greater savings than have been possible on the mainland, especially with the high prices for lumber here.

The following are the specifications for the preservative treatment of ties by pressure processes drawn up by the Committee on Treatment of Ties of the American Wood-Preservers' Association and reported at its 1924 meeting:

SPECIFICATION FOR THE PRESERVATIVE TREATMENT OF TIES BY PRESSURE PROCESSES.

General Requirements.

1. The following general requirements (2-8) apply to each of the treatment processes.
2. *Conditioning.* Ties shall be conditioned for treatment in accordance with American Wood-Preservers' Association "Standards for the Purchase and Preservation of Treatable Timber." (See A. W. P. A. Manual of Recommended Practice.)
3. *Seasoning.* (a) Ties shall be seasoned, by air or steam as agreed upon, until in the judgment of the purchaser's representative any moisture in the wood will not prevent the injection and proper distribution of the specified amount of preservative.
 (b) When, in the judgment of the purchaser's representative, steam-seasoning is necessary for adequate treatment, cross-ties may be steamed in the cylinder at not more than 30 lbs. pressure per square inch for not more than 10 hours at not more than 275° F., which pressure and temperature maxima shall not be reached in less than two hours. The cylinder shall be provided with vents to relieve it of air and insure proper circulation of steam. After steaming is completed a vacuum shall be maintained at a temperature as high as practicable until the wood is as dry as practicable. The cylinder shall be relieved continuously or frequently enough to prevent condensate from accumulating in sufficient quantity to reach the wood. Before the preservative is introduced the cylinder shall be drained of condensate.
 (c) Ties seasoned by boiling in preservative shall not be heated above the minimum temperature sufficient to evaporate the moisture under the existing pressure. Boiling shall

continue until the rate of condensation of water does not exceed 1/10 of a pound per cubic foot of wood per hour.

4. *Preparation for Treatment.* Any charge of ties shall be confined to one kind or designated group or kinds of wood, of pieces approximately equal in size and moisture and sapwood content, into which approximately equal quantities of preservative can be injected, on which all necessary framing, boring, or chamfering shall have been done, and so separated as to insure contact of preservative, and steam if used, with all surfaces.

5. *Manner of Treatment.* The ranges of pressure, temperature, and time duration shall be controlled so as to result in maximum penetration by the quantity of preservative injected, which shall permeate all of the sapwood, and as much of the heartwood as practicable. The vacuum requirements stipulated are those at sea-level, and necessary corrections shall be made for altitude.

6. *Retention of Preservatives.* No charge shall contain less than 95% nor more than 110%, of the quantity of preservative that may be specified. The amount of preservative retained shall be calculated on the basis of preservative at 100° F., from readings of working-tank gauges, or scales, or from weights before and after treatment of at least 1/5 of the number of loaded trams on suitable track scales, checked as may be desired by the purchaser's representative.

7. *Determination of Penetration.* Penetration shall be determined by sampling ties in each charge, as may be desired by the purchaser's representative. Any holes which may be bored shall be filled with tight-fitting treated plugs.

8. *Plant Equipment.* Treating plants shall be equipped with the thermometers and gauges necessary to indicate and record accurately the conditions at all stages of treatment, and all equipment shall be maintained in condition satisfactory to the purchaser. The apparatus and chemicals necessary for making the analyses and tests required by the purchaser shall also be provided by plant operators, and kept in condition for use at all times.

Preservatives.

9. The preservative or preservatives used shall be the most suitable and available of the following standards of the American Wood-Preservers' Association:

- Creosote Oil (Grade 1) for Ties and Structural Timber.
- Creosote Oil (Grade 2) for Ties and Structural Timber.
- Creosote-Coal-Tar Solution for Ties and Structural Timber.
- Creosote Oil (Grade 3) for Ties and Structural Timber.
- Zinc Chloride.
- Water-Gas-Tar Solution for Admixture with Zinc Chloride.
- Water-Gas-Tar Distillate for Admixture with Zinc Chloride.

Amount of Preservatives To Be Used.

10. Creosote:

- Full-cell process, at least 10 lbs. per cubic foot of cross-ties.
- Empty-cell process, without initial air, at least 6 lbs. per cubic foot of ties.
- Empty-cell process, with initial air, at least 5 lbs. per cubic foot of ties.

Zinc Chloride:

- One-half pound dry salt per cubic foot of ties.

Creosote-Zinc Chloride:

- Three pounds of oil and one-half pound of dry salt per cubic foot of ties.

Treating Operations.

11. (a) Oil Treatment:

Full-Cell Process.

Empty-Cell Process, without initial air.

Empty-Cell Process, with initial air.

(b) Salt Treatment.

(c) Oil-Salt Treatment.

Oil Treatment.

12. *Full-Cell Process.* (a) Ties shall be subjected to a vacuum of sufficient intensity and duration to insure that the wood is as dry and free from air as practicable, and to permit a retention of the specified number of pounds of preservative per cubic foot of wood. In no case shall the vacuum be maintained at less than 24 ins. for less than 30 minutes.

(b) The preservative shall be introduced and the cylinder filled without breaking the vacuum. The pressure shall then be raised gradually to and maintained at a minimum of 100 lbs. per square inch until the required quantity of preservative is injected into the wood, or until the purchaser's representative is satisfied that the largest volumetric injection that is practicable has been obtained. The temperature of the preservative during the pressure period shall be not less than 150° F., nor more than 200° F., and shall average at least 180° F. After pressure is completed the cylinder shall be emptied speedily of preservative, and a vacuum of not less than 22 ins. promptly created and maintained until the ties can be removed from the cylinder free of dripping preservative.

13. *Empty-Cell Process, With Initial Air.* (a) Ties shall be subjected to air pressure of sufficient intensity and duration to provide under a vacuum the ejection of surplus preservative, and to insure a retention and proper distribution of the specified number of pounds of preservative per cubic foot of wood.

(b) The preservative shall be introduced between 150° F. and 200° F., the cylinder pressure being maintained constant until the cylinder is filled with preservative. The pressure shall then be raised gradually to and maintained at a minimum of 150 lbs. per square inch until there is obtained the largest practicable volumetric injection that can be reduced to the required retention by a quick high vacuum, or until the purchaser's representative is satisfied that the largest volumetric injection that is practicable has been obtained. The temperature of the preservative during the pressure period shall be not less than 150° F., nor more than 200° F., and shall average at least 180° F. After pressure is completed the cylinder shall be emptied speedily of preservative, and a vacuum of not less than 24 ins. promptly created and maintained for not less than 30 minutes until the quantity of preservative injected is reduced to the required retention and the wood can be removed from the cylinder free of dripping preservative.

14. *Empty-Cell Process, Without Initial Air.* (a) The preservative between 150° F. and 200° F. shall be introduced to the ties until the cylinder is filled. Pressure shall then be raised gradually to and maintained at a minimum of 100 lbs. per square inch until there is obtained the largest practicable volumetric injection that can be reduced to the required retention by a quick high vacuum, or until the purchaser's representative is satisfied that the largest volumetric injection that is practicable has been obtained. The temperature of the preservative during the pressure period shall be not less than 150° F., nor more than 200° F., and shall average at least 180° F. After pressure is completed the cylinder shall be emptied speedily of preservative and a vacuum of not less than 24 ins. promptly created and maintained for not less than 30 minutes until the quantity of preservative injected is reduced to the required retention and the wood can be removed from the cylinder free of dripping preservative.

Salt Treatment.

15. (a) The treating solution, which shall not have a strength exceeding 5%, determined by the American Wood-Preservers' Association "Standard Method of Analysis for Zinc Chloride," and which shall be no stronger than necessary to obtain the required retention of preservative with the largest volumetric absorption practicable, shall be thoroughly mixed before use.

(b) Air-seasoned cross-ties shall be steamed in the cylinder for not less than one hour or more than two hours, at a pressure of not more than 20 lbs. per square inch. After steaming is completed a vacuum of at least 24 ins. shall be maintained for not less

than 30 minutes until the wood is as dry and free of air as practicable. If the vacuum is broken while the condensate is being drained from the cylinder a second vacuum as high as the first shall be created. The preservative shall be introduced without breaking the vacuum until the cylinder is filled. The pressure shall then be raised gradually to and maintained at a minimum of 100 lbs. per square inch until the required quantity of preservative is injected into the cross-ties, until less than 5% of the total quantity required has been injected during the latter half of one hour throughout which the rate of injection has persistently decreased while the pressure has been held continuously at 150 or more pounds per square inch. The temperature of the preservative during the pressure period shall be not less than 140° F., nor more than 170° F., and shall average at least 150° F. After the pressure is completed the cylinder shall be emptied speedily of preservative and a vacuum of not less than 24 ins. promptly created and maintained for not less than 30 minutes or until the wood can be removed from the cylinder free of dripping preservative.

Oil-Salt Treatment.

16. (a) The preservative mixture shall be composed of the volumetric proportion of creosote oil and zinc chloride solution of the necessary strength required to obtain the specified retention with the largest volumetric injection that is practicable, and shall be agitated in the working tank and cylinder so as to insure thorough mixing before and while the cylinder is being filled with preservative, and while the preservative is being injected into the ties. The strength of the zinc chloride solution shall not exceed 5% and shall be determined by the American Wood-Preservers' Association "Standard Method of Analysis for Zinc Chloride."

(b) Air-seasoned ties shall be steamed in the cylinder for not less than one hour, nor more than two hours, at a pressure of not more than 20 lbs. per square inch. After steaming is completed a vacuum of at least 24 ins. shall be maintained for not less than 30 minutes until the wood is as dry and free of air as practicable. If the vacuum is broken while the condensate is being drained from the cylinder, a second vacuum as high as the first shall be created. The mixture of preservatives shall then be introduced without breaking the vacuum until the cylinder is filled. The pressure shall then be raised gradually to and maintained at a minimum of 100 lbs. per square inch until the required quantity of preservative is injected into the ties, or until less than 5% of the total quantity required has been injected during the latter half of one hour throughout which the rate of injection has persistently decreased while the pressure has been held continuously at 150 or more pounds per square inch. The temperature of the preservative during the pressure period shall be not less than 150° F., nor more than 200° F., and shall average at least 180° F. After the cylinder is emptied of preservative, a vacuum of not less than 24 ins. shall be maintained until the timber can be removed from the cylinder free of dripping preservative.

[H. A. L.]

Sugar Prices.

96° Centrifugals for the Period
March 17, 1924 to June 11, 1924.

Date	Per Pound	Per Ton	Remarks
Mar. 17, 1924.....	6.845¢	\$136.90	Cubas, 6.91; Porto Ricos, 6.78.
“ 19.....	6.65	133.00	Cubas.
“ 20.....	6.75	135.00	Porto Ricos, 6.78, 6.72.
“ 25.....	6.65	133.00	Porto Ricos.
“ 28.....	6.78	135.60	Cubas.
April 1.....	6.65	133.00	Cubas.
“ 3.....	6.50	130.00	Cubas, 6.53, 6.47.
“ 4.....	6.53	130.60	Porto Ricos.
“ 5.....	6.65	133.00	Porto Ricos.
“ 8.....	6.53	130.60	Cubas.
“ 9.....	6.40	128.00	Cubas.
“ 10.....	6.435	128.70	Cubas, 6.40, 6.47.
“ 11.....	6.28	125.60	Cubas.
“ 14.....	6.09	121.80	Cubas, 6.15, 6.03.
“ 15.....	5.90	118.00	Cubas.
“ 16.....	6.28	125.60	Porto Ricos.
“ 21.....	6.15	123.00	Porto Ricos.
“ 22.....	6.2167	124.33	Porto Ricos, 6.15; Philippines, 6.22; Cubas, 6.28.
“ 23.....	6.40	128.00	Porto Ricos.
“ 25.....	6.28	125.60	Porto Ricos.
“ 30.....	6.215	124.30	Porto Ricos, 6.28; Cubas, 6.15.
May 1.....	6.03	120.60	Cubas.
“ 5.....	5.90	118.00	Cubas.
“ 7.....	5.78	115.60	Cubas.
“ 12.....	5.84	116.80	Cubas, 5.90, 5.78.
“ 13.....	5.5467	110.93	Cubas, 5.65, 5.53, 5.46.
“ 14.....	5.53	110.60	Cubas.
“ 15.....	5.715	114.30	Cubas, 5.78, 5.65.
“ 16.....	5.745	114.90	Cubas, 5.78, 5.65, 5.71; Philippines, 5.84.
“ 19.....	5.65	113.00	Cubas.
“ 20.....	5.53	110.60	Porto Ricos.
“ 22.....	5.40	108.00	Porto Ricos.
“ 24.....	5.15	103.00	Porto Ricos.
“ 26.....	5.055	101.10	Cubas, 5.09, 5.02.
“ 27.....	5.005	100.10	Porto Ricos, 5.02; Philippines, 4.99.
June 2.....	5.21	104.20	Porto Ricos.
“ 3.....	5.12	102.40	Cubas, 5.15, 5.12; Porto Ricos, 5.09.
“ 4.....	5.055	101.10	Cubas, 5.09, 5.02.
“ 9.....	5.15	103.00	Cubas.
“ 10.....	5.085	101.70	Cubas, 5.15, 5.02.
“ 11.....	5.02	100.40	Cubas.

THE HAWAIIAN PLANTERS' RECORD

Volume XXVIII.

OCTOBER, 1924

Number 4

A quarterly paper devoted to the sugar interests of Hawaii and issued by the Experiment Station for circulation among the Plantations of the Hawaiian Sugar Planters' Association.

An International Conference of Cane Sugar Men Meeting as the sugar section of the First Pan-Pacific Food Conservation Conference, representatives from various parts of the cane sugar world held discussions on technical problems of common interest, July 28 to August 14, 1924.

There were thirteen sessions in all. The subjects which received attention are listed as follows, with the names of those presiding as leaders of the discussions:

- July 29—Sugar Cane Breeding (continued August 5), E. W. Brandes.
- July 30—Sugar Cane Quarantine, H. L. Lyon.
- August 1—Methods of Cultivation, Hunter Freeman.
- August 4—Varieties and the Jeswiet Identification System, Mario Calvino.
- August 5—Cane Diseases, D. S. North.
- August 6—Bud Selection, H. F. Clarke.
- August 6—Cane Entomology, O. H. Swezey.
- August 7—Soils and Fertilizers, Kintaro Oshima and G. R. Stewart.
- August 8—Rodent Control, C. E. Pemberton.
- August 11—Factory Engineering, Norman Kay.
- August 11—Factory Operation and Control in Sugar Cane Factories, W. R. McAllep.
- August 13—Irrigation, Wm. P. Alexander.

Those who participated in the discussions, listed by countries, were:

Australia—

- M. S. Barnett, Head of Technical Field Section, Colonial Sugar Refining Company.
- Hunter Freeman, Field Officer, Colonial Sugar Refining Company.
- D. S. North, Plant Pathologist, Colonial Sugar Refining Company.

Continental United States—

- E. W. Brandes, Pathologist in Charge, Sugar Plant Investigations, U. S. D. A.
- T. D. A. Cockerell, Professor of Zoology, University of Colorado.
- C. L. Marlatt, Chairman, Federal Horticultural Board, U. S. D. A.
- Herbert Osborn, Research Professor, Ohio State University.

Cuba—

Mario Calvino, Director, Experiment Station of Chaparra Sugar Company.
 Ralph Wood, Manager, Chaparra Sugar Company.

Fiji—

Harry Flockton Clarke, In Charge Agri. Experiments, Colonial Sugar Refining Company.

Formosa—

Migaku Ishida, Chief of Sugar Exp. Sta., Government Research Institute.
 Kintaro Oshima, Director, Dept. Agr., Government Research Institute.

India—

R. L. Pendleton, formerly of India, now with University of Philippines.

Mexico—

R. H. Van Zwaluwenburg, Entomologist, United Sugar Companies.

Philippine Islands—

H. Atherton Lee, formerly of the Philippines, now with H. S. P. A. Experiment Station.
 R. L. Pendleton.

Porto Rico—

Norman Kay, Chief Engineer, Central Aguirre Sugar Company.

Hawaiian Islands, U. S. A.—

H. P. Agee	H. Atherton Lee	Walter E. Smith
W. P. Alexander	H. L. Lyon	J. B. Steffee
J. D. Bond	W. R. McAllep	G. R. Stewart
W. van H. Duker	W. L. McCleery	O. H. Swezey
C. F. Eckart	W. W. G. Moir	J. A. Verret
W. G. Hall	S. S. Peck	J. W. Waldron
R. H. Hughes	C. E. Pemberton	John M. Watt
Horace Johnson	J. Lewis Renton	F. X. Williams
Ernest Kopke	John A. Scott	J. N. S. Williams
Y. Kutsunai	Twigg Smith	

Notes from the International Conference

Factory Operations (By W. R. McAllep)

On Monday, August 11, the program of the sugar section of the Pan-Pacific Food Conservation Conference was given over to discussing factory operations. In the morning Mr. Norman Kay, Chief Engineer of Central Aguirre, Porto Rico, led the discussion from an engineering standpoint. In the afternoon session technical considerations and chemical control were taken up with W. R. McAllep leading the discussion.

Mr. Kay gave an interesting talk on grooving with particular reference to handling returned settlings from the Petree process. The problem was solved by replacing the customary 60° grooving with grooving of 37½° angle and ½ inch pitch. The extraction was higher than before the Petree process was installed but moisture in bagasse was in excess of 50 per cent.

Mr. Ralph Wood, administrator of the Chaparra estate of the Cuban-American Company, spoke of milling under Cuban conditions. On account of an ample supply of cheap cane and a limited grinding season, extraction is considered secondary to capacity. Double crushers with 60° grooving, 3-inch pitch on the first and 1.5-inch pitch on the second, together with comparatively coarse grooving on the following units, have been found the best solution of this problem of passing a large tonnage of cane through the mill.

Mr. Barnett, of the Colonial Sugar Refining Company, spoke of milling practice in Fiji and Australia. The type of shredder known in Hawaii as the National is used in many mills. Extraction is obtained by a combination of milling and diffusion. In some factories long maceration baths, similar to those at McBryde Sugar Company are used. In other factories large annular drums containing revolving rakes are installed between the mills. In both cases the apparatus is kept partly filled with maceration water. The partly crushed cane averages about fifteen minutes in passing through them. The maceration baths are kept hot to prevent bacterial action and lime is added to reduce inversion.

Mr. Duker spoke on the importance of having Krajewski crusher rolls mesh properly.

Under the subject of milling practice in Hawaii, Mr. Hall spoke on the advantages of the Searby shredder.

Discussion centered largely on efforts during the last few years to improve mill sanitation, including replacing the old slat conveyors with the Ewart, Ramsey, and Meinecke types, the installation of juice pans with steep sides under the mills, the use of antiseptics around the mill and efforts to overcome the objectionable features and deficiencies of the conventional type of juice strainer, including returning the juices used as maceration without straining, the type of pump used for this purpose and the Peck strainer.

Mr. Kopke discussed centrifugal separation applied to handling settlings and other factory problems.

The afternoon session was opened by outlining the work of the Sugar Technology Department of the Experiment Station of the H. S. P. A.

Under the subject of clarification, Dr. Ishida stated that 8 of the 45 factories in Formosa made white sugar for direct consumption, using the carbonation process. Dr. Ishida also described the clarification process for use in direct consumption sugar manufacture developed by him at the Formosa Experiment Station. Ammonium and magnesium acetates are used. The increase in purity is as much as 7 or 8 points. The process has been tried out on a factory scale but is not yet used commercially. Filtration was one of the principal difficulties encountered.

The general discussion of clarification included the work in recent years at the H. S. P. A. Station, the Petree process and Dr. Horne's process. Under the discussion of the Petree process it was pointed out that while increases in extraction have been secured after installing it in cases where extraction is comparatively low, in Hawaii with high extractions a loss in extraction has followed its installation. The danger of inversion during the lengthened settling time was also pointed out. Favorable results in clarification were attributed more to the efficiency of the Dorr clarifier than to the process itself.

In the discussion of Dr. Horne's process, it was brought out that juices are first limed, heated and settled. Sodium phosphate is then added, replacing lime salts with the more soluble sodium salts, after which the juice is resettled. This has interesting possibilities in the way of reducing scale in evaporating apparatus and in reducing ash in the sugar. It is certain that most excellent clarification can be secured in any juices with this process.

During the discussion of refining qualities of sugar the fact was brought out that the Colonial Sugar Refining Company, which refines its own raws, produces sugars of 98.5 or higher polarization. The average polarization in Cuba was stated to be about 96.5.

Determining the amount of sugar entering the mill on the cane carrier was the principal subject discussed under Chemical Control. No satisfactory method has been developed for determining this directly. In Java, the Philippines, Formosa and Cuba it is calculated in approximately the same manner as in Hawaii; that is, sugar in bagasse is added to sugar in the mixed juice, and the sum accepted as the sugar in the cane, undetermined losses at the mill being disregarded. In Fiji and Australia sugar in the cane is calculated from the first expressed juice analysis using the following formula:

$$\begin{aligned} s &= \% \text{ sucrose in juice from front roller of first set;} \\ f &= \% \text{ fibre in cane;} \\ \text{then,} \\ \% \text{ sucrose in cane} &= \frac{s \times (100 - (f + 5))}{100} \end{aligned}$$

Efficiencies of different mills are compared on the basis of the ratio of a factor termed "Pure Obtainable Cane Sugar" to the sugar recovery in the bags. The factor "Pure Obtainable Cane Sugar" is calculated as follows:

$$\begin{aligned} s &= (\text{same as above}) \\ f &= (\text{same as above}) \\ S &= \% \text{ sucrose in cane (as above)} \\ b &= \text{brix of juice from front roller of first set} \\ \text{then,} \\ B = \text{Brix of cane} &= \frac{b \times (100 - (f + 3))}{100} \\ \text{and} \\ \text{P. O. C. S. in Cane} &= S - \frac{1}{2} (B - S) \end{aligned}$$

In Cuba, boiling house efficiencies are calculated on the basis of Winter's formula. The quality ratio table formerly used in Hawaii is the reciprocal of the value obtained by this formula.

After a discussion of the difficulty in understanding manufacturing data reported from different countries and the desirability of having a uniform basis, the following resolution was adopted:

Be it Resolved, That in view of the difficulty in interpreting the figures obtained in the chemical control exercised in the sugar industry, it is desirable to adopt a uniform system of reporting data obtained in the manufacture of cane sugar, to the end that figures reported in one country may be understood in every other cane-producing region.

Sugar Cane Diseases (By H. Atherton Lee)

Root-rot was the opening subject of the discussion on cane diseases at which Mr. D. S. North, of Australia, presided.

The root-rot of Louisiana was described by Dr. E. W. Brandes of the U. S. Department of Agriculture, Washington, D. C. He stated that R. D. Rands, also of the Department of Agriculture, had found the cause of the root trouble in Louisiana. Dr. Brandes mentioned that he recently visited fields of some of the plantations here on Oahu, and, on Lahaina cane at Ewa Plantation, had found an organism similar to the causal organism of root-rot in Louisiana. A cable had just been received from Dr. K. F. Kellerman of the Department in Washington permitting the release of information, then in press, purporting to establish the cause of root-rot of sugar cane in Louisiana.

Dr. Brandes proceeded to say that in Louisiana small holes were found upon the roots, resulting in the root destruction, and that Mr. Rands had shown that a small mollusc or snail of the genus *Zonitoides* was responsible for these holes. A description of the holes was given.

Mr. Otto H. Swezey immediately brought out the point that investigators in Hawaii were familiar with these snail punctures, and he had mentioned four species of these molluscs in one of the publications of the Experiment Station, several years previously. He stated his view, however, that the work of the molluscs could not be considered responsible for what is called Lahaina disease here in Hawaii.

Mr. H. Atherton Lee pointed out that the injuries resulting from molluscs were not alone associated with root-rot of Lahaina cane; but that some of the healthiest Lahaina cane, as well as Yellow Caledonia, D 1135, and H 109 would often show attacks of the molluscs. Cane affected with these mollusc holes of the roots did not in many instances evidence any indication of Lahaina disease.

Dr. Harold Lyon brought out the same point and also stated that Mr. Cyril E. Pemberton had shown that in addition to the molluscs, a centipede would cause similar holes on cane roots. Mr. Pemberton mentioned the facts leading to the finding of the relationship between the holes and the centipedes. Many of the holes were smaller than those caused by molluscs and were too small to be

accounted for in that way. A study of the problem had therefore been made, and centipedes definitely associated with these very small holes.

Returning to the question of the relationship between the molluscs and Lahaina disease it was brought out that the collection of these molluscs was made by Dr. Brandes from the field at Ewa in which Mr. W. T. McGeorge had shown the high salt concentration. Mr. McGeorge had subsequently shown rather clearly in culture studies that the Lahaina trouble in this field was due to this high salt concentration.

Under these circumstances the injuries resulting from the molluscs were apparently secondary, or at least a minor factor in causing the trouble. Mr. W. P. Alexander, of Ewa Plantation, described the area in which the molluscs had been found and corroborated the statements concerning the high salt concentration of the area.

Dr. Lyon pointed out that there were a number of root troubles; that Lahaina disease which was at one time considered to be due to a single cause had now resolved itself into at least three distinct troubles. He stated that the matter of the molluscs would no doubt be gone into thoroughly.

Mr. Guy R. Stewart related the methods of attack on Lahaina disease by the soil investigators. In several instances salt concentration had been shown by Mr. McGeorge to be high enough to be responsible for what was called Lahaina disease. In another district high acidity with a high concentration of soluble aluminum salts were held responsible for what had also been called Lahaina disease.

Two root diseases of cane were known in Formosa, according to Dr. Migaku Ishida, but he stated that not much progress had been made concerning their nature. In Australia, according to Mr. D. S. North, a root disease occurs which is one of their serious troubles. He related experiments in which they were able to transmit the root disease by butt cuttings. There are apparently several types of root troubles in Australia, according to Mr. North.

Mr. North then pointed out the need for knowledge of cane diseases in the various cane countries; with such knowledge, spread of such diseases to new countries could then be easily prevented. The more serious cane diseases of Australia were listed as follows: Gum disease caused by *Bacterium vascularum*; leaf scald caused by a bacterial organism not yet published upon; Fiji disease, the cause of which is unknown; mosaic disease, the cause of which is also unknown; downy mildew caused by a fungus, *Sclerospora sacchari*; red rot; various root rots; rust caused by the fungus *Puccinia kuehnii*; top rot; leaf sheath rots probably caused by *Rhizoctonia* and *Sclerotium* species; and knife cut.

Mr. North asked Mr. Lee to list the cane diseases of Hawaii and also of the Philippines.

The Hawaiian Islands were stated by Mr. Lee to be rather fortunate, in their comparative freedom from serious cane diseases. Although many planters in Hawaii felt that all cane diseases were present in Hawaii, compared with Australia, Java, India, Formosa or the Philippines this country is fairly free of cane diseases. The diseases here in order of the losses caused at the present time would probably be as follows: Mosaic disease, Lahaina disease, red stripe, eye-

spot, Pahala blight, iliau, sectional chlorosis, ring spot, pineapple disease of standing cane and leaf freckle. Red rot has been recorded in Hawaii only once; a leaf spot caused by a fungus of the genus *Phyllosticta* was also observed once or twice. Of these diseases, mosaic disease causes little or no loss on most plantations, although on a few plantations attention is necessary to prevent material losses which are now occurring. The other diseases are causing very slight losses throughout the Territory at the present time.

In the Philippines, the following diseases are known: Fiji disease, leaf scald, cane smut, mosaic disease, downy mildew, eye spot, a flowering parasite somewhat similar to the mistletoe that lowers the quality of the cane juices enormously, ring spot, red rot, pineapple disease of cuttings and of standing canes, pokkah bong, sclerotial banded disease, a leaf spot caused by the fungus *Cercospora kopkei*, another spot caused by a fungus of the genus *Pestalozzia*, another leaf-spot caused by a fungus, *Phyllachora sacchari*, rust caused by the fungus *Puccinia kuehnii*, sooty mould, sheath spot caused by the fungus *Bakkerophoma sacchari*, wilt caused by the fungus *Cephalosporium sacchari*, and leaf freckle, the cause of which is unknown.

The fundamental policy in cane disease control for the Hawaiian Islands, according to Mr. Lee, was to exclude those diseases occurring in other countries which had not yet reached this country. Control of most of these foreign diseases could be effected but it would cost money and it would be much cheaper to exclude the diseases than to combat them once they became established here.

Dr. Ishida listed the diseases known in Formosa, mentioning especially mosaic disease, red rot, pineapple disease, two kinds of root disease, and many other troubles which are in the course of investigation.

In Cuba, Dr. Mario Calvino, of Central Chaparra, mentioned mosaic disease and a trouble which he called blight.

The question of the importation of cane diseases on bamboo poles, or leaves used as packing material, was raised by Mr. E. M. Ehrhorn, Chief of the Plant Inspection Service in Hawaii. It was agreed by the delegates that such importations were a possible source for the admittance of organisms, possibly of minor importance on bamboo, but under certain climatic conditions or on certain varieties might be serious on cane. It was the consensus of opinion that the matter should be looked into more fully.

Gumming diseases were next discussed by Mr. North. Gum disease in Java was distinct from gumming disease in Australia, but was very similar to leaf scald which occurs in Australia. Leaf scald is characterized by leaf streaks which afford the chief symptom for identification.

These streaks become visible as soon as the leaf unfolds and turns green. The larger ones may even be faintly discerned in white immature leaves unfolded by hand. They occur either on the midrib or on any part of the leaf blade or leaf sheath. Some of them traverse the whole length of the leaf. As they strictly follow the course of the vascular bundles, those located on one side run out on the leaf margin at the top end. But the smaller ones instead of traversing the whole length may fade away after running a certain length. They are straight, well defined, narrow, even streaks, creamy, almost pure white in color.

They persist as long as the leaf remains green, but with age they tend to broaden out and become diffused, afterwards withering; this process usually commences towards the leaf tip and works downward. Reddish spots or blotches may also appear on them. Numerous bacteria are found in these streaks in microscopic sections, located in the xylem elements of the vascular bundles.

In the stem, numerous reddened vascular bundles are to be found, more especially in the nodes. They even occur in the embryonic tissues almost up to the growing point. Shooting of the eyes is most pronounced, even the immature eyes near the growing point usually showing a tendency to shoot. The side shoots display symptoms (leaf streaks, etc.) analagous to those of the main stem. They are particularly valuable for identification purposes in more mature canes, because leaf streaks can often be found on them, when they have been obscured by withering on the leaves of the main stem.

Mr. North also described the leaf streaks of gumming disease. The streaks are not present as a rule when a leaf first unfolds, but they develop in the mature leaves, thus being found chiefly on the older leaves. They occur most commonly towards the leaf tips, but may occur on any part of the leaf blade. In color they are yellow and marked with tiny reddish brown spots. They are fairly straight but have irregular margins and do not so strictly follow the course of the vascular bundles as the leaf-scald streaks do. They keep on growing in length, the older portions withering and the leaf tending to split. Typically, the withered portions occur towards the leaf tip, but often streaks consist of a central withered portion, with a live yellow portion at each extremity. In rare cases, streaks are found present when a leaf unfolds and turns green, then having every appearance of having travelled up from the stalk below. These streaks sometimes closely resemble those due to leaf scald of the broader spreading type, especially if, as sometimes occurs, they are devoid of the brown spots and run the whole length of the leaf.

Dr. Lyon again emphasized the need for keeping leaf scald and gumming disease out of Hawaii, since he believed these diseases would be very serious here.

The matter of sectional chlorosis was brought up by Mr. Alexander. Mr. North stated that they had this trouble in Australia and that it was especially common on the variety D 1135. In Australia it was believed to be associated with cold weather when standing water existed around the central cylinder of the stalk.

Dr. Brandes said they had this trouble in Louisiana and had at first considered the cause of much the same nature as described by Mr. North. Later, however, they obtained the disease in their greenhouses in Washington, eliminating the possibility of its being associated with cold weather. He believed the trouble to be due to either extreme of temperature when there was an accumulation of water in the leaf spindle.

In Hawaii the disease has been reported from Olaa, Honokaa, Ewa and Waianae, according to Mr. Lee, but usually has disappeared without any serious harm, within one or two months. The theory of frost injury, as advanced in Australia, apparently could not be applied to such conditions as exist at Ewa and Waianae. The varieties affected have been D 1135 and H 109.

Sugar Cane Quarantine (By H. L. Lyon)

On Wednesday morning, July 30, the delegates of the cane sugar section assembled at the Territorial Plant Quarantine Station and inspected the laboratory and equipment employed in carrying out the local quarantine regulations. They then visited the cane quarantine house of the Hawaiian Sugar Planters' Association. This house was not entered but was carefully inspected from the outside. The delegates next assembled in the administration building of the Sugar Planters' Experiment Station and engaged in a general discussion of the subject of sugar cane quarantine. The points of especial interest to Hawaii brought out in the discussion may be summarized as follows:

As the sugar cane plant was not indigenous in Hawaii, all diseases and insect pests specific to this plant now present in these islands must have been introduced from outside sources. It follows, therefore, that had adequate quarantine measures been in force from the very first, cane in Hawaii might still be nearly or quite free from its specific enemies.

Laws regulating or prohibiting the importations of propagating material of sugar cane can be considered detrimental only to the country making these laws. It is no hardship to any cane-growing country to have cuttings of its cane varieties refused entrance into any other cane-growing country.

Travel and commercial intercourse between countries afford many avenues through which cane insects and diseases may be transferred from one country to another. It is quite impossible to close some of these avenues and impracticable to close others by quarantine regulations. It is obvious, therefore, that no practical quarantine can afford absolute protection against the entrance of the insect pests and diseases of the sugar cane into new territory.

While the danger of general dissemination of cane insects and diseases will grow with the increase of travel and commerce between the countries of the Pacific, still the danger will, at the same time, be lessened through the growing knowledge of these pests and the application of successful measures of control in the various cane-growing countries where they occur.

It is quite possible to surround the importation of cane cuttings into a country with such precautions that the liability of introducing insect pests and diseases with the cane will be less than that attending ordinary travel and commercial intercourse. This condition has quite evidently been attained through the quarantine measures now in force in Hawaii.

While there is no case on record where a cane disease or insect pest has been transferred from one country to another on dry cane tassels, still it is quite possible that certain cane diseases may be carried on such material and importations of seed should always be handled with great care.

Sugar Cane Entomology (By O. H. Swezey)

The session of the sugar industry section of the Pan-Pacific Food Conservation Conference occurring on the afternoon of August 6, was devoted to discussions on sugar cane entomology. Mr. Swezey was the leader and at the be-

ginning of the program gave a somewhat lengthy account of the major sugar cane insect pests in Hawaii, the history of their occurrence, whence they came, their habits and the damage caused. The method of controlling these pests by the introduction of natural enemies was outlined, with an account of the different parasites introduced for the respective pests.

Pest	Introduced Parasites	From
Cane Borer, <i>Rhabdocnemis obscura</i>	<i>Ceromasia sphenophori</i>	New Guinea
Leafhopper, <i>Perkinsiella saccharicida</i>	<i>Paranagrus optabilis</i>	Australia
	<i>Anagrus frequens</i>	Australia
	<i>Cyrtorhinus mundulus</i>	Australia
	<i>Ootetrastichus beatus</i>	Fiji
	<i>Haplogonatopus vitiensis</i>	Fiji
	<i>Pseudogonatopus hospes</i>	China
	<i>Ootetrastichus formosanus</i>	Formosa
Root grub, <i>Anomala orientalis</i>	<i>Scolia manilae</i>	Philippines
<i>Aphis sacchari</i>	Several ladybeetles	Australia
	<i>Micromus vinaceus</i>	Australia
Leafroller, <i>Omiodes accepta</i>	<i>Chalcis obscurata</i>	Japan
	<i>Microbracon omiodivorum</i>	Japan
	<i>Trichogramma minutum</i>	U. S. A.

Mr. H. Freeman, of the Colonial Sugar Refining Company, gave an account of experiments in the control of the cane grubs in Queensland. The two species most injurious to cane there are *Lepidoderma albobirtum* and *Lepidiota frenchi*, and loss by their grubs often is as much as 60 per cent. The adult beetles have their flights at certain definite seasons, and "it was found that there were two main reasons why any particular field of cane was selected by the beetles for the deposition of eggs. These were: (1) the height of the cane, and (2) the proximity to feeding trees. As an example, it was found that fields of cane which were six to nine feet high at the time of the beetle flight were infested to extent of an average of 6 to 14 grubs per stool; whilst cane which was only 6 to 18 inches high averaged considerably less than one grub per stool. From this a control measure was evolved in which a fast growing variety was planted during the beetle flight and pushed ahead by the use of a suitable manuring program." The beetles went to other fields of higher cane for egg laying and this field grew a crop without infestations. By harvesting fields just before the beetle flight, the new ratoons would also similarly escape becoming infested.

This control measure could not be utilized on all fields on account of various labor considerations. By experiment it was determined that a saturated solution of paradichlorobenzol in carbon bisulphide was 2 or 3 times as efficient as either of the constituents used alone. A mortality of 80 per cent to 90 per cent of the grubs was obtained by using this fumigant. The increased yield obtained due to the fumigation made it a profitable investment. This fumigation had no detrimental effect on the growth of the cane providing it was over 4 or 5 months old. Younger cane was seriously affected.

Mr. Barnett, also of the Colonial Sugar Refining Company, told of the cane borer Tachinid being established in northern Queensland, and that it is being distributed to other parts of the State. He also told of its being established and

doing well on the Rewa River, Fiji, but that it has not succeeded on the opposite side of the island, though continued efforts have been made to establish it there. The borer has destroyed as much as one-third of the season's sugar crop at one center. Referring to a recent report by Mr. Veitch, Entomologist of the Colonial Sugar Refining Company, Mr. Barnett discussed some minor pests of sugar cane in Fiji. Among them was the armyworm, and he spoke very highly of the value of the mynah bird in preventing armyworms and grasshoppers from becoming extremely destructive pests.

Mr. Ishida, Chief of Shinka Sugar Experiment Station, Formosa, read two papers, one on "The Application of *Metarrhizium anisopliae* for the Control of *Allisonotum impressicole* and Allied Beetles," in which it was shown that the use of the fungus reduced the number of beetles and grubs about 50 per cent; the other paper was on "The Application of *Phanurus beneficiens* Against Stalkborer and its Result." This is an egg-parasite introduced from Java in 1916, and it has succeeded so well, along with other egg-parasites already present, that at present the damage to the cane from stalkborers is not serious.

Professor Osborn, of Ohio State University, who has made much study of leafhoppers and their economic importance, cited cases of the migration of some species from tropical America north into the United States, and warned of the likelihood of such species becoming pests in the new places they invaded. He said that in a recent letter from an entomologist in Africa, the corn leafhopper was said to have been found infesting cane. It has never yet been known to do this in Hawaii.

Dr. Williams, who had recently returned from a two years' parasite trip in various South American countries, read a paper on "Insects Affecting Sugar Cane in South American Countries." In this paper the worst pests in various places respectively were: Barbados—root grubs, *Phytalus smithi* and *Diaprepes abbreviatus*; Trinidad—the froghopper, *Tomaspis varia*; British Guiana—moth borers, *Diatraea* spp.; Brazil—froghoppers and *Ligyris* beetle; Ecuador—moth borers, *Diatraea* spp. and weevil borer, *Metamasius*. Many other minor pests were mentioned. The most of these cane pests are insects native to the regions, and previously feeding on other plants, but have taken to feeding on cane after the introduction of the latter by man. Some of them are partially controlled by natural enemies.

Mr. Kay stated that the principal cane pest in Porto Rico is the white grub.

Professor Cockerell, of the University of Colorado, stated that he had noticed by a report from the entomologist in Egypt, that the mealybug, *Pseudococcus sacchari*, was the worst cane pest they had there, and that it really threatened the prosperity of the sugar industry in Egypt. While in Madeira Islands a few years ago, Professor Cockerell had found this same mealybug, but exceedingly scarce, apparently being destroyed by the larvae of a small *Leucopis* fly. This should be worthy of investigating further, for it might be that the fly could be introduced to Egypt or other countries desiring enemies to this particular mealybug.

Mr. Pendleton reported termites to be the worst cane pests in Gwalior State, India. They often eat the seed before it begins to germinate. If they do not attack the cane until it is pretty well grown, they work up through the stool in the

inside of the cane, filling the stalk with mud as they go. Many insecticides have been tried, but all ineffectual. The second pest is the cane borer.

In the absence of Mr. Van Zwaluwenburg, of Los Mochis, Mexico, Mr. Swezey presented for him a paper on the "Insect Enemies of Sugar Cane in Mexico." Two Pyralid moth borers, *Chilo loftini* and *Diatraea lincolata*, were mentioned as the only serious enemies of sugar cane in the state of Sinaloa, the former being by far the more important. No field methods for controlling it have been found. It infests many grasses, also corn, sorghum, and rice. A few native parasites attack this pest, chief among which is a *Chelonus* that has been known to parasitize as high as 23 per cent. Although second in importance, *Diatraea lincolata* has been known to infest from 35 per cent to 60 per cent of the cane stalks. It is primarily a pest of the plant cane. This is better controlled by natural enemies than *Chilo*.

The eggs are often parasitized to the extent of 70 per cent by *Trichogramma minutum*. In one state a Braconid, *Apanteles diatraeae*, has parasitized as high as 50 per cent. Attempts have been made with introduction of four parasitic flies, two from Cuba, one from Vera Cruz, and one from New Orleans, but so far none of them have been recovered. Minor cane pests in Mexico are: armyworms, leafhoppers, froghoppers, Membracids, the cane lacewing, mealybugs, and a weevil borer, *Sphenophorus incurrens*.

Rodent Control (By C. E. Pemberton)

In the session of the sugar section of the Food Conservation Conference devoted to rodent control, it was of particular interest to learn:

1. That rats actually do cause serious losses to cane in other countries. For instance, Mr. M. S. Barnett, of the Colonial Sugar Refining Company of Australia, stated that in 1921 a loss of 4 per cent of the total crop at two of their Australian mills, was attributed to rat activities.

2. That systematic poisoning has been proven effective in rat control in Australia and Cuba, though it has not been so extensively conducted as in Hawaii.

3. That phosphorus is the favored poison in Australia, and strychnine in Cuba. Barium carbonate has apparently not been tried in other countries to any great extent.

4. That rats are not so chronically serious in other cane countries as in parts of Hawaii, and that this condition is probably owing to the presence of natural rodent enemies such as snakes, owls, and hawks, in those countries. Mr. H. Freeman referred to the carpet snake of Australia, stating that it was common in some cane fields and that he had in many instances found the remains of rats inside them. Mr. Barnett also stated that these snakes had been seen to catch rats in buildings in Australia. They are not poisonous. Mr. Wood, of Cuba, also referred to two non-poisonous Cuban snakes which are said to be good ratters. Dr. F. X. Williams noted a non-poisonous British Guiana snake known as the "Yellow Tail," which is considered a very good rat catcher.

Interesting mention was also made by Mr. Barnett of useful hawks in Australia; by Dr. Williams of a beneficial bird of prey, the Caracara of Ecuador; by Mr. Wood of an iguana, owls, and hawks, of Cuba; and by Mr. Freeman of a so-called iguana of Australia, and of useful hawks. All admitted that these various natural enemies of rats had a weakness for chickens.

5. That rats in Australian cane fields damage cane only in sections of fields adjacent to permanent water supply. This point, brought out by Mr. D. S. North, is of particular interest, because rat damage in Hawaiian cane fields shows no relation, so far as observed, to the availability of water.

Sugar Cane Breeding (By Twigg Smith)

The good results that have attended careful crossing of sugar cane varieties is creating more interest in this type of seedling propagation.

The object of all cane breeding work is to obtain a cane which will have a combination of the qualities that are necessary for the production of a high sugar yield. Many canes otherwise good are weak in stooling or subject to attacks by disease.

Again, a hardy, heavy tillering cane may not produce enough sugar to make it a commercial cane.

The combination of good qualities of different varieties, then, would constitute the super-cane.

An endless amount of effort spent year after year in producing hybrids, by any method, from any two varieties, has little chance of success in producing the super-cane unless (a) proper study is given to the inherent characteristics of the parents; (b) their behavior under climatic conditions where the seedlings are to be grown commercially; (c) whether their characteristics, desirable and undesirable, are capable of being transmitted to their hybrid offspring.

Already certain characters and qualities of sugar cane have proved to be transmissible.

The discussion for the most part was by men actually engaged in sugar cane breeding work. The outline presented by Dr. Brandes for thorough discussion of the subject follows:

1. Selection of parents.
2. Varieties naturally inclined to bloom.
3. Environmental conditions affecting blooming or maturity.
 - a. Latitude, daylight.
 - b. Altitude.
 - c. Temperature.
 - d. Drought or excessive rain.
4. Technique of crossing.
 - a. Methods for determining viability of pollen:
 - (1) Iodine test.
 - (2) Germination on stigmas of other plants.
 - (3) Germination on sugar solutions.
 - b. Methods for collecting and preserving pollen.
 - c. Periodic viability of pollen during blooming season.

- d. Methods of applying pollen:
 - (1) Dusting.
 - (2) Suspending male panicles.
- e. Diurnal variation in opening of florets.
 - (1) Receptive period of stigmas.
- f. Protection of fertilized flowers against contaminating pollen:
 - (1) Cloth bags.
 - (2) Waxed paper bags.
 - (3) Isolation by distance.
- g. Harvesting of seed:
 - (1) Bagging previous to maturity.
- h. Viability of perfect seed:
 - (1) Time to plant.
 - (2) Time required for germination.
- i. Methods of planting:
 - (1) Rate of planting and position in relation to medium.
 - (2) Soil.
 - (3) Water requirement.
 - (4) Provisions for preventing seed mixtures or pot contaminations by wind.
- j. Transplanting—elimination of undesirable seedlings.
- k. Packing seed for shipment.
- l. Uniform methods for designating parents and time of producing seedlings by standard record.

Dr. E. W. Brandes said: "If we hope for progress in the way of actually improved varieties we have to go into breeding much deeper than just taking any two canes and crossing them: we must make a study of the possibilities that lie in the various varieties and fit them in with the various problems that have to be met. Conditions may arise, such as the introduction of a new disease, which may make new varieties necessary."

Selection of Parents: Under this heading it was stated that each country had its disease troubles, and the natural desire is to get a cane that would be immune to disease and at the same time be a good sugar producer.

In Hawaii, efforts are being made to combine the desirable characters of H 109, Badila, and D 1135 on one side, with the hardier, disease-resistant and heavy stooling character of Uba,* in an effort to avoid eye-spot, root-rot, yellow stripe, mosaic, etc. Also the so-called Tip canes are being crossed with D 1135 for higher lands. The Tip canes are vigorous growers at high elevations, but susceptible to mosaic and to red stripe disease. On the other hand, D 1135 is very resistant to eye spot, mosaic, and red stripe disease, and ratoons well, but does not do as well as the Tip varieties above 1500 feet elevation.

We are also trying many field-gathered crosses of H 109 and D 1135.

Mr. Clarke said that in Fiji, Badila is favored as a mother cane, and they would like a combination with such a cane as Yellow Caledonia or H 109.

Mr. Ishida said that in Formosa, their main enemy is sereh, and that effort was being made to get seedlings resistant to it. They are trying several varieties, including Yellow Tip, Rose Bamboo, Badila, and Kassoer.

In Cuba, Dr. Calvino stated that Uba, with D 74 as a male parent, had been useful in producing disease-resistant seedlings. They also imported seedlings from

* The local cane of the Chinese type labelled "Uba," and not yet positively identified.

Barbados and British Guiana. The parentage was not stated. Dr. Calvino said they took a great interest in raising seedlings because the seedlings may show characters which were not apparent in the parent canes.

Mr. Pendleton said that the problem in northern India is to produce a thick cane that will grow well under adverse conditions, notably, low humidity, little irrigation, and serious infestation of termites. In reply to a question, he stated that experiments had demonstrated that the thin-stick North Indian varieties were out-yielded by their hybrids having larger sticks.

The question of transmission of susceptibility to disease by parents to seedlings was discussed at considerable length.

Mr. Agee cited the case of H 109, an Hawaiian seedling which is planted to 70,000 acres and gives very high yields and is immune to what is termed Lahaina disease or root rot. This cane is a seedling of Lahaina, which is extremely susceptible to the disease. The seedling H 109 was produced without knowledge of its male parent, but it is thought to be Rose Bamboo or the family to which Rose Bamboo belongs. Rose Bamboo is also susceptible to Lahaina disease. Both Rose Bamboo and Lahaina failed at Ewa plantation, where the world's record yields have been made by their progeny, H 109. Another instance is a cane we call the Uba Hybrid No. 1. We were very desirous of obtaining a cane immune to yellow stripe disease. Following the lead of Dr. Calvino of Cuba, we crossed Uba with D 1135, both parents being commercially resistant to yellow stripe. The hybrid No. 1, however, has well developed cases of yellow stripe or mosaic.

"I think," said Mr. Agee, "that these two cases prove that we cannot be too closely bound by theory in cane breeding."

Dr. Brandes expressed the opinion that the cases mentioned by Mr. Agee were exceptions which prove the rule that like produces like, and that a cane immune to disease has a greater chance to produce immune offsprings. He also pointed out that he had seen yellow stripe on D 1135 in the Philippines.

Mr. Agee stated that at Honokaa a fair percentage of Uba seedlings had yellow stripe disease. It was important, he thought, to note and study these exceptions to what might be expected. It is not the characteristics of the parent canes that we are primarily concerned with, but the characteristics that they are capable of transmitting to their progeny.

Dr. Brandes stated that in trying to get a variety resistant to sereh, in Java, they had crossed their Black Cheribon with Chunnee from northern India. They succeeded in getting seedlings, immune to sereh, but susceptible to other diseases, notably, yellow stripe or mosaic. At the present time they are concentrating on crosses of native canes and the primitive types of sugar cane. The seedlings obtained are then crossed with the heavy-yielding canes, and they have now several promising seedlings, such as P. O. J. 2714, 2725, etc., which are resistant to most diseases. Many of them are commercially immune to mosaic and also the disease referred to as root disease.

Mr. Barnett stated that in the case of a New Guinea variety called Mahona, imported to New South Wales, it was noticed that it had a tendency to die off in the tropics, due, it was discovered later, to a disease called leaf scald. Many seed-

lings had been raised from Mahona, and the majority inherited susceptibility to the disease.

Under the topic of "Blooming or Tasseling," it was brought out that all varieties bloom in Hawaii, and it seems well established that the blooming is best in the medium altitudes. Instances were cited where, on Hawaii, cane did not bloom at 3,000 feet nor at 50 feet, but did bloom between these levels.

It was stated that all varieties bloom at times in Fiji and Formosa.

It seemed generally accepted that anything that checks the growth of the cane seems to cause the plant to arrow, tasseling being considered a normal process of sugar cane.

Under the heading of the "Technique of Crossing," the first discussion was on the methods of determining the viability of pollen. The method favored at present at this Station is to determine by microscopic examination if the pollen is spherical and contains granules, in which case it is considered normal. The presence of starch as indicated by the well-known iodine reaction test is in exact relation to the normal state of pollen grains, which are spherical, juicy, and full of granules of starch. We did not succeed in germinating pollen on any of the artificial media tried last year.

Dr. Calvino told of success in germinating pollen on stigmas of other plants, but not in any solution. Mr. Clarke reported a complete lack of success in germinating pollen in any way in Fiji.

Dr. Brandes said that in Florida they had successfully used the moon vine, a species of *Ipomoea*.

In Hawaii, the method of collecting pollen has been to suspend the tassels over a table, which is covered with black paper, and as soon as the pollen had dropped, to sweep it into a container and immediately dust it on the stigmas. No satisfactory method of preserving pollen has been found; rather, it seems to be very fugitive, quickly drying under changes of temperature and humidity. We have never been able to keep it looking spherical above 10 minutes if exposed to much light.

Under the topic of "Periodic Viability of Pollen," Dr. Brandes pointed out that observation had been made in many places that pollen may be viable at the beginning of the tasseling period and worthless toward the end, and that it is extremely important that we should know just the best time, with each variety we desire to use, to take pollen for cross pollination. The period of non-viability of pollen would be the best time to use that particular variety as a female parent.

No definite data appeared to have been kept as to the best method of applying pollen to the stigmas of the female variety.

Good results have been secured in Hawaii by two methods, tying the male and female tassels together, and by collecting the pollen on paper and brushing it on the stigmas.

Speaking on the variation in the receptive condition of stigmas, Dr. Brandes stated that under local conditions in Florida it had been found that stigmas of sugar cane were receptive from 3:40 A. M. till daylight. An effort will be made in Hawaii this year to determine that for our varieties.

It was generally agreed by those who had used bags to protect the tassels that it is not to be recommended. The tassels are weakened, and germination of the seed is weakened. In general, where a large number of seedlings are wanted, it seems to be considered enough to gather the pollinated tassel in the field from a place where it is fairly reasonable to suppose the desired cross has been effected. Until some method of carrying on artificial cross pollination on a large scale is found, this method of getting crosses will probably continue in most countries.

Dr. Brandes stated that in Florida they now make a practice of waiting a week or so after the last male tassel has been placed in contact with the female, and then put a cloth bag over the pollinated tassel to prevent wasting of prospective seedlings. In Hawaii, the practice is to wait till the fuzz flies from the top of the tassel on being lightly tapped. The tassel is then considered ripe enough to gather. Sometimes the panicle is cut in sections for planting so as to avoid the loss of mature parts.

The time that seed can be held before being planted seemed to vary in each country. In general it seemed that the sooner it was planted the better, although Dr. Brandes told of seed sent from India to Washington, D. C., which germinated very well.

On the question of how long the fuzz should be kept in the hope of germination, it was brought out that cane tassels had continued to give germination for as long as thirty days.

Mr. Kutsunai outlined the Hawaiian method of planting seed, which is to distribute the fuzz on top of sterilized garden soil and sand. The fuzz is kept very moist.

The method of Mr. W. P. Naquin, at Honokaa Sugar Company, of using well-seasoned filter press cake alone, on which the fuzz was spread, has given remarkable results, and probably is as good a medium for getting germination as any used so far.

Dr. Brandes said the U. S. Experiment Station in Florida uses clean fresh-water sand, which is practically sterile, and from which they have had good results.

Mr. Clarke stated that in Fiji they use a glass house, and the temperature ranges from 120° in the day to 60° at night, but even at that they get very excellent germination.

Mr. Agee stated that large cold frames with glass protection were used very successfully in Kohala and Hamakua. These gave a very high temperature.

Steam heat will be tried as a subsoil heat this year in Hawaii, and Dr. Brandes stated it was his intention to try the same in Florida.

Also this year in Hawaii some seedlings will be germinated in a glass house so made that it will be possible to roll the flats out in the fresh air on still, dry days. The time of germination in Hawaii is January and February, which are normally the wettest months.

In discussing the elimination of undesirable seedlings it was brought out that in Fiji, Formosa and in Florida it is customary to discard by inspection, after one year's growth, from 95 to 98 per cent of the canes. In Hawaii, the initial

discard is not so high, usually being from 60 to 80 per cent, sometimes 90 per cent.

Dr. Lyon questioned the advisability of severe elimination of canes the first year, and thought that there was an opportunity for valuable scientific investigation in this connection. Both he and Mr. North cautioned against selecting with a preconceived type in mind, feeling that the superior cane sought in this work may appear in a form different from the commercial canes of today. Mr. North cited Badila as an example of a valuable cane which would be eliminated if grown in competition with other varieties closely spaced about it.

Mr. Moir strongly favored ratooning the original seedling plants and cited the Wailuku seedlings in support of his contention. Initial selections based on plant cane were found inferior by him to canes originally overlooked and afterward selected by him from the old ratoons of the original plants. Mr. Kutsunai pointed out that at the Manoa substation a large number of seedlings were being ratooned this year from the original plants, and he stated that with one exception he had been able to select as plant cane those seedlings which afterward showed to good advantage as first ratoons.

On the question of the spacing of the original plants, it was found that spacing of four or five feet was utilized in Fiji and Formosa and even wider spacing in Florida. In Hawaii, a spacing of plants three feet apart in five-foot rows has been gradually reduced to two feet. On the strength of recent trials of five-foot spacing, however, there is an inclination to adopt this in the future.

Dr. Brandes described a score card system of judging canes with the view of reducing to a minimum the personal equation in selection. Cane breeders in Hawaii, Fiji and Formosa agreed to give this score card system a trial under their conditions. Dr. Brandes laid great emphasis on the strong root system. This, he said, must be considered as a prerequisite of any seedling that is to be retained.

It was also pointed out that when one adopts wider spacing or is slower in eliminating apparent undesirables in a large block of seedlings, he thereby curtails the space that might be devoted to newly propagated ones. To thus reduce the number of germinations is in effect an elimination in itself of those not germinated, and this must be borne in mind in any further study to perfect our methods.

Bud Selection (By Y. Kutsunai)

Mr. Harry Flockton Clarke, of Fiji, presided at this meeting.

That there are mutations of sugar cane is an established fact. The sporting of Striped Mexican into Rose Bamboo, of Red or common D 1135 into yellow-striped D 1135 and bronze-striped D 1135, and finally into the so-called white D 1135; of H 109 into striped H 109, and of Yellow Caledonia into striped Caledonia of various colors, is very well known to Hawaii and needs no evidence to prove its occurrence. The color mutations are naturally the first to be noticed because the mutating qualities are not only clearly visible but also are *independent* of the environmental factors.

The heavy-yielding mutations, which are also thought to exist, as indicated by several tests, are not clearly seen on account of the overpowering environmental influences. How often these heavy-yielding mutations occur and recur in the cane fields is not definitely known at the present state of knowledge of the subject. The frequency with which the striped sport of H 109 occurs may possibly throw some light on the point in question. Eight stools of striped H 109 were found in about 25,000 stools of H 109, or a ratio of 1 in 3,000, roughly. A high-yielding mutation, if rare, as it is thought by some to be, and masked by the environmental factors is not easy to spot. The history and the methods of selecting or isolating high-yielding mutations so far evolved or suggested, and the attending difficulties were well discussed and many points of interest were set forth. A review of these points and ideas follows.

The work of selecting mutations in sugar cane by Mr. A. D. Shamel was begun in 1920. His first activity was that of training a staff of selectionists to develop keen powers of observation. The course consisted of taking a very detailed census of a cane row, noting the position of the stalks, the number of stools per seed piece, the number of stalks arising from a single eye, the length, circumference, and weight of the stalks, the number of joints in the stalks, juice analyses, color types, and uniformity.

When the staff became sufficiently acquainted with the cane plant, the actual selection of superior stools was initiated. The cane selected was always plant cane.

The fundamental idea of the bud selection is to segregate a given variety of sugar cane into its component strains and at the same time to isolate any mutation that may exist or be thrown out in the course of work. From such strains and mutations, the high-yielding lines are to be isolated. These isolated lines may revert back to the original variety or may throw off other new lines.

Two lines of procedure have been developed. In one, a plot of cane is stripped and every stool is examined. Superior stools of cane are chosen for further trial. Due allowance is made for extraneous influences, such as a near-by watercourse or a ditch, proximity to the edge of the field, etc., at the time of judging the stools. The other method consists of covering as wide an area as possible, without the preliminary stripping and picking out of very striking stools, and planting them under uniform conditions for further selection.

In applying the theory of bud selection to practice, two tendencies have been developed. In the one case, the selectionists have laid stress on the so-called types, or conformation of sugar cane. The erect, semi-erect, and the recumbent types of H 109 have been studied carefully in relation to the yielding power of the types. The selectionists of this school hold that a variety of sugar cane, H 109, for instance, is made up of many strains that are well nigh stable. The segregation or resolving of a variety into its component strains is followed by the comparative studies of the segregated strains in order to find the most desirable one. The other school believes that the high-yielding quality of a variety of sugar cane may be correlated with two kinds of characters, visible and invisible. Selection

based on this idea is necessarily very wide in its latitude. Not only all the promising types are accepted, but also all the superior stools are selected for further trial.

The selection work seems to be a rather involved proposition on account of the overwhelming environmental influences which obscure the differences in the yielding qualities of various strains of a sugar cane variety. Consequently the work is now taking a decided turn and the problem of the immediate future is the development of methods by which the disturbing environmental factors may be unified or held in check. The most important cause of the difficulty is the uneven distribution of the elements on which the cane makes growth, such as light, fertility, and water. The "necessities of growth," if allotted to each stool in equal amounts, the inherent characters of the stools become apparent. The method that promises to, in part, fulfill the desired aim, is spaced planting. The selected stools are planted far enough apart so that each stool can have more room for natural development.

Another turn that is taken in the procedure of bud selection work is the study of ratoons. Heretofore most of the work was done in plant crops about a year old. It is reported that a ratoon crop, especially an old ratoon crop, has been noted to be very promising material for selection.

On the whole, the problems confronting selectionists are very much more involved than anticipated. Unless one is fully prepared to meet discouraging results, and unless one has firm conviction and faith in the work, and has originality and resourcefulness to overcome the stumbling blocks that beset the work of bud selection, he is likely to fall short of his goal.

Sugar Cane Cultivation (By J. A. Verret)

The meeting was presided over by Mr. Hunter Freeman, of Australia. Those taking part in the discussion were Messrs. M. S. Barnett and H. Freeman, of Australia; Mr. H. F. Clarke, of Fiji; Messrs. Kintaro Oshima and Migaku Ishida, of Formosa; Mr. R. H. Van Zwaluwenberg, Mexico; Dr. Mario Calvino, Cuba; Mr. R. L. Pendleton, India; and Messrs. H. P. Agee, Guy R. Stewart, W. P. Alexander and J. A. Verret of Hawaii.

We shall outline briefly important points brought out in discussions in the order in which they were presented.

As this is intended for Hawaii readers, for the sake of brevity, parts of the discussion relating to Hawaii will be omitted.

Rotation and Green Manuring: Dr. M. Calvino, speaking for Cuba, pointed out that no rotation is practiced in Cuba, and no irrigation. In a few cases some green manuring is being done experimentally. The velvet bean is used for this purpose with good results. Jack beans have also been tried. The velvet beans are planted broadcast, and plowed in before they mature seed.

Mr. Pendleton, speaking for India, said that agricultural conditions were rather poor in that country. In preparing the land for cane, a wooden, steel-tipped plow is used. This goes down, at the most, about four inches. But the Indian farmers

make up for this to some extent by plowing the land as much as twenty times before planting.

A system of rotation for sugar cane has been recently introduced with promising results. It is one of three years, and starts with sugar cane, planted in the winter season. This grows for one year, and no ratoons are taken. After harvest the land lies fallow until the rainy season, about June or July, when san hemp, *Crotalaria juncea*, is planted. This is plowed under in September, after which the land is planted to wheat. This crop gets one or two irrigations, and is harvested in March or April. The land remains idle until June, when another legume, guar, *Cyamopsis psorolioides*, is planted. This is cut about September, and used for fodder, sometimes being made into silage. Cane follows this, being planted about December, starting a new cycle. Some irrigation is practiced. This applies especially to northern India. The yields are rather small in India, 18 tons of cane per acre being about maximum.

In Fiji there is no irrigation. As a general rule three crops are raised, one plant and two ratoons. This is followed by a green manure crop, black Mauritius beans usually. A fair crop of beans gives about 10 tons of green matter per acre. This is plowed under.

In regard to trash conservation, Mr. Clarke, speaking for Fiji, made the following statement: "Formerly we saved the trash. This was made into piles between the cane rows and after the harvesting of the last crop this accumulation of trash was plowed under. We found a certain benefit from this, but we also found certain disadvantages. The ratoons were hampered in their growth by the banks of trash, which did not rot readily. At that time we were only growing plant and first ratoon crops. Now we do not save any trash except that from the last ratoon crop."

Mr. Van Zwaluwenberg, referring to the western part of Mexico, said that irrigation was the common practice. The fields are ratooned from two to four times. The old lands generally raise but two ratoons. The cane is followed by alfalfa. This grows for two years, cutting the first year and grazing the second. In some cases a short cover crop is put in. This is planted in May or June, and grazed. Cane follows, being planted in the fall or spring. The cane grows for 18 months to 2 years.

In Formosa, some areas are irrigated and some are not. The cane crops consist of one plant and one ratoon. This is followed by a crop of sweet potatoes, and this in turn by peanuts. Cane ratoons very poorly in Formosa.

In Louisiana, a three- or four-year rotation is followed. This consists of one plant crop of cane, one ratoon, and then corn and cowpeas, the cowpeas being plowed under. The four-year rotation is the same except that there are two years of cowpeas and corn instead of one. Cane in Louisiana is about a 9 months' crop. Frosts kill the cane down in winter. These frosts are likely to come along any time from November to March. The average yearly yields of cane vary from about 11 to 18 tons per acre.

In Queensland and New South Wales, the practices are given as follows by Mr. Freeman: "The plant crop is usually about 15 months old and the ratoon crop

occupies the land for 12 months. Generally speaking, we cut two ratoon crops, but on some occasions it runs to third ratoons. This depends upon the prospect of a profitable yield. The trash is certainly not saved. The period of fallow varies, but usually it is only a matter of time sufficient to prepare the land for a subsequent crop. Undoubtedly there are farms that practice green manuring, and they find the benefits of it. It gives handsome yields in Queensland. I think there are various reasons for that, but mainly it serves as a weed control, and supplies humus. The green manure crops are Mauritius beans and cowpeas. Of these the Mauritius bean is undoubtedly the better, for the reason that it holds the ground longer. But it must be plowed under before it produces seed. The ground is well covered for four or five months. We get maximum yields of 10 to 15 tons of green matter per acre. In Queensland we might say that the average cane crop is about 20 tons per acre. We get maximum yields of 60 to 70 tons per acre from year-old crops, but they are exceptional, and these only occur on new lands, recently brought under cultivation. In New South Wales, the climate is colder and the rainfall more even. There we have two-year-old crops, of both plant and ratoon cane with yields of 50-100 tons per acre. Very little green manuring is regularly practised, but there is a certain amount of rotation with corn. There is very little done in the way of green manuring, either in Queensland or in New South Wales, but we feel the want of it very badly. There is one point in connection with green manuring that may interest you. For instance, with Mauritius beans, sown broadcast, we use a bushel of seed to the acre, whereas with a drilling machine half that quantity is sufficient, and one man can cover four to five acres per day. It is quite evident that there are many different opinions on the question of rotation practice. Hawaii stands in marked contrast to the other countries in getting increasingly better results without either resting the land or by green manuring. After thirty years of cane growing here, they still get increasing yields from the same land, but in Queensland the opposite is the case. The longer we grow the cane there, the lower the yields, unless we practice green manuring."

Preparing a Field for Planting: New lands in Cuba are not plowed, as these are generally forest lands. Holes are made among the stumps with picks or other sharp instruments, and the cane planted in them. On the lands which are plowed, some of the smaller tractors are used, plowing to less than 12 inches. Oxen are still very extensively used for plowing.

As stated above, the Indian uses a steel-tipped wooden plow for his plowing, with which he may scratch the field 20 times. The other work is largely by hand. The manure is placed in the furrow and well mixed with the soil about six weeks before planting.

The cane is irrigated and has frequent cultivations, gradually filling in the furrow so that by the beginning of the heavy rains in June or July the cane is well hilled.

In Fiji, in plowing in trash, a 4-mule, single-furrow plow, with a 26-inch disk, is used. The furrowing is done with a double mould board to a depth of 7 or 8 inches.

Some steam plowing (Fowler) is done on one plantation. Some tractors are used, the largest being about 45 h. p.

In Formosa, native plows and some tractors are used. The native plows go in about 5 inches. Seven or eight sets of Fowler steam plows are also used. Tractors and steam plows are used on the large plantations only. The small farmers confine themselves to the native plows. Fordson and Case are types of tractors used.

Mr. Freeman gave an interesting resume of the work in Queensland and New South Wales. We quote him: "In regard to Queensland and New South Wales, the plows are of various types. Usually disc plows are used in all preparatory cultivation work. One of the great obstacles in returning humus to the soil in preparatory cultivation has been the difficulty in finding plows suitable for turning under trash or bean crops. Special study has shown that a single furrow disc plow gives best results. The secretary disc is very satisfactory in so far as it has an arched beam which allows of great clearance. But we have modified the first furrow wheel and land wheel by using parts from more up-to-date plows, whilst the rear furrow wheel has been substituted by a disc Coulter. The sharp edge of this Coulter bites into the bottom of the furrow at the junction of the land and the furrow. Thus, by means of thrust, we have achieved what most plow manufacturers try to attain by weight. In consequence of this device, the plow is held to its work. Another point in regard to the satisfactory plowing under of green crops is that the disc needs to be as upright as possible; it must be at least 28 inches in diameter, and the edge kept as sharp as a razor by means of a long bevel and the constant use of a file. The dish of the disc should also be quite pronounced, and the furrow cut by it a full 12 inches. It is just these details which mean successful plowing.

"We believe that the desirable depth of cultivation is about 12 inches, but do not always achieve that. We are using more and more tractors every day. Steam cultivation is not used. My opinion is that a track-laying tractor is the only type to use. Many of the smaller tractors which work with one wheel in the furrow are employed. These are not necessarily preferred, but it is more a case of the inability of small farmers to purchase the larger or more efficient implement. Tractors give us a greater independence of labor by reason of their speed, and this speed is also a factor of importance in fitting in our work with weather conditions. They help us in labor problems, but, I am sorry to say, do not always mean more efficient work."

Planting: In India, whole stalks are planted without cutting, no top seed being used. The fields are irrigated ahead of planting, and the seed buried in the mud by hand (or feet, perhaps is a truer expression).

In Fiji, planting material is obtained from special fields called "seed beds." These are about ten months old when cut, and the whole stalk is used. In planting, the seed is placed 2 feet center to center, with rows $5\frac{1}{2}$ feet apart. The seed is covered with $\frac{1}{2}$ to 1 inch of soil in the rainy season and with about 3 inches in dry weather. When planting is done in the spring top seed is used, as the "seed beds" are not then ready.

These "seed beds" are carefully observed, and if any diseases, such as Fiji disease or mosaic, appear, the field is discarded for seed purposes. On this account both Fiji disease and mosaic appear to be under control, there being but little of either.

Except for this careful inspection for disease, these "seed beds" are not treated differently from the other fields.

In Cuba, as mentioned previously, forest lands are planted with a pick, using short seed. Another method is by means of a sharp, hardwood stick. The laborer walks along, and, at proper intervals, drives the stick in the ground at an angle; the stick is pressed up and pulled out, after which a seed is placed in the hole and the ground pressed about it with the feet. The advantages claimed for this system are that the seed has the benefit of the moisture in the bottom of the hole, and aeration, sunshine and heat at the surface.

Another system being tried out on a commercial scale was described by Dr. Calvino. This is called the Abreu system.

In this system the land is prepared and two seeds are planted in squares eight feet each way and covered with an inch of earth. No holes are used. At harvest only mature stalks are taken, the others are allowed to grow. As we understand this, mature stalks mean all millable cane. The stalks left behind are the immature suckers. Wagons are driven in between the cane rows to haul the cut cane.

In Formosa, both top seed and body seed are used. The seed is planted at an angle of 60° to 70°, and spaced 14 inches in four foot rows.

Mr. Freeman has briefly outlined conditions in Queensland as follows: "In regard to Queensland, usually we take seed from plant crops if possible. Some fields are often planted as seed beds, but no special precautions are taken in regard to them. In many cases seed cane is purchased from a neighboring farmer, but usually it comes from his own farm. We prefer plant cane about 9-10 months old. The seed is cut at right angles to the stalk and the ends are not shattered. This is possible with a soft cane like Badila, but the hardness of H 109 might force us to cut it on a slant as is done in Hawaii. We are afraid of the slanting cut on account of the greater area exposed to drying out. We usually use the whole stalk, but experimental evidence has shown that the tops give increased yields and slightly sweeter juice. These experiments were very carefully conducted. We do not soak the seed cane in water before planting unless the conditions are very dry. It is then a distinct advantage. Hand planting is a thing of the past. Queensland was the inventor of machine planting. It is a question of labor shortage, and I do not doubt but that very shortly you will be using machine planting here. These machines are of simple construction, consisting essentially of a box on wheels with a funnel through which the seed is dropped into the furrow whilst two feet on the rear of the machine cover over the pieces. Usually they work in the furrow, which has been made by a double mould board plow. The main feature about them is that they do the work well and save labor. Two units of labor will do more than five times as much work with the machine as they can with hand planting."

In Louisiana, whole stalks are used for seed. The bulk of these come from the poorest ratoon fields, and up to very recently no attempt was made at selection. Planting takes place in autumn or spring. The autumn planting takes place in September or October, before harvesting begins. The spring planting starts in February and proceeds as fast as weather allows. The seed for spring planting has to be kept over winter and protected from frost. This is done by cutting two rows on one, placing the cane in the furrow and covering with earth several inches deep. This keeps fairly well through the winter. The autumn planting remains in the ground all winter and begins to germinate in February or March, depending on the coldness of the season.

It is now becoming customary to plant a cover crop of sour clover on autumn plant fields. This is turned under when cultivation starts in the spring.

In preparing for planting, the fields are laid out in rows 5 to 6 feet apart. A planting furrow is made in the center of this row, not as deep as the bottom of the furrows between the cane rows, in order to allow for drainage. Wagons with the seed cane are driven in the fields and drop the cane in the furrow, usually two running stalks. Boys follow behind with cane knives, place the cane properly in the row, and cut the stalks into shorter lengths so as to have proper contact with the soil. Disc cultivators follow behind and cover the seed several inches deep.

In the spring the cane is off-barred, and excess dirt removed to allow germination. The off-barring incidentally covers most of the sour clover.

Soils and Fertilizers (By G. R. Stewart)

The meeting of the sugar section which dealt with soils and fertilizers was fortunate in having a group of delegates present from many of the important cane sugar countries of the world. The following cane regions had one or more representatives: Australia, Cuba, Fiji, Formosa, India, the Philippines, and Hawaii. A great diversity of conditions and agricultural practice was revealed in these different regions. It may be illuminating to summarize some of the outstanding observations upon sugar cane soils, and their fertilization, in these widely separated districts.

Australia: The principal sugar cane regions are in New South Wales and in Queensland. Both these districts are part of the coastal plains which extend north and south along the shores of the Australian continent for over 1400 miles. The Queensland cane estates lie in the northern section of this coastal belt, and the New South Wales cane land in the southern.

The soils planted to sugar cane show quite a wide variation. They may be divided roughly into the soils of the alluvial flats and the forest soils. The alluvial flats are deep soils which have been deposited along the banks of the rivers. This land was originally covered by a dense growth of tropical scrub. The soils formed under these conditions are inherently very rich.

The forest soils are, in general, lighter in texture than those of the alluvial flats, though occasional areas of clay occur in this forest land. The greatest dif-

ference between these two soil types is in productivity. The forest soils are notably poorer in yield than the alluvial flats.

There are also limited areas of true volcanic soils which are very similar to some of the soils of the Hawaiian Islands. In general, the Australian volcanic soils are more porous and open in texture than those found in Hawaii. This volcanic land is extremely deep and is inherently rich soil. In all the Australian cane land, moisture is the greatest limiting factor. This open texture of the volcanic soils, therefore, favors the passage of rainfall far down below the roots of the cane plant, and makes the growth of a crop a very great problem in dry weather.

Very little chemical work has been done upon the Australian soils. Dr. Maxwell made a small beginning in chemical work years ago when he was first in Australia. This work did not continue for any great length of time, though for many years government reports have been issued giving the analyses of the soils from various districts. These analyses were not correlated with any field experiments or attempts to determine the productivity of this land. There are no special problems of soil fertility under investigation in either sugar cane region at the present time.

The fertilizer practice which appears to give the best response in Australia is the use of green leguminous cover crops. The trash is usually burned before cutting the cane, in Queensland, and it is becoming very apparent that this is leading to gradual exhaustion of the organic matter of the soil. The use of green manuring crops has not become universal, but there is strong evidence that it is the best treatment for the cane lands of Australia.

At the present time, it is a fairly general practice to apply about 400 to 600 pounds per acre of a phosphatic fertilizer containing about 5 per cent to 7 per cent of nitrogen and 14 per cent to 16 per cent of phosphoric acid. This fertilizer is put on in the drill at the time of planting. If the ratoons are fertilized, it is customary to apply ammonium sulfate, but most of the fertilizer is applied to the plant crop at the time of planting. This practice is believed to stimulate germination of the cane and force the young growth ahead, so that weeds are more easily controlled. The cane crop in Australia is grown for a period of about twelve months, and the average yield of cane is about 25 long tons, or 28 short tons per acre.

Cuba: In Cuba, practically all the sugar cane lands are formed on a limestone base. There are two general types of soils: the dark red soils, and the heavy, black clay loams. For many years it was believed that cane could only be grown upon the red soils. It has now been proven that the best yields are obtained from the black soils. The red soils are very deficient in humus. Green manuring crops such as velvet beans and cowpeas are now being tried to restore the fertility of the older cultivated red soils.

All the cane soils have an apparently inexhaustible supply of lime. It was formerly believed that all that was necessary to restore the fertility of the sugar cane lands was to allow them to go back into wild growth as forest land. This is a very slow process for building up organic matter in the soil. The use of green

cover crops promises to be a much more rapid and effective way to restore fertility.

No extended chemical studies have been carried out on the Cuban soils and no fertilizers are being used at the present time. Nearly all the sugar companies have more land available for cane than is now under cultivation. With this extra land to draw upon, if necessary, and a sugar market which does not warrant a great expansion in production, the tendency in Cuba is to produce cane by the smallest possible outlay. The usual system followed is to cut the cane without firing. The cane tops are used as feed for the bullocks which draw the cane wagons and plow the fields.

The cane trash is allowed to lie in the fields and forms a heavy mulch which effectually prevents weed growth. The plant crop and the first ratoons will ordinarily require considerable cultivation and hoeing. After these two crops have been harvested there is ordinarily sufficient trash to keep down the weeds. The maximum crops obtained are about twenty-five tons of cane per acre. The average crop would probably be from fifteen to twenty tons of cane. The cane fields are ordinarily ratooned for fifteen to twenty years. Fields are not ordinarily replanted till the production of cane has fallen to about eight tons of cane per acre. The crop is grown for about twelve months, all fields being ordinarily cut each year.

Fiji: The best cane lands in Fiji are the alluvial flats, which lie between the low hills bordering the valleys and the rivers flowing through the center of them. A less desirable type of cane land lies further back at the base of the hills, where the soils are partly transported and partly formed of residual material by the weathering of the rocky deposits on the hill slopes. The poorest soils are the upper portions of these slopes, where the land has been subject to excessive washing and erosion.

At the present time, no chemical investigations in soil fertility are under way in Fiji. Many carefully controlled plot experiments have been carried out, comparing local seedlings with standard canes, and contrasting various soil and fertilizer treatments.

As a result of this work, green manure crops have been established as the best fertilizer treatment for the cane lands. On the best lands greater tonnages of cane could be obtained by additional fertilizer applications. The Fiji cane grower has actually found that it is not profitable to raise this maximum crop because of damage which will occur to it before harvest. Badila cane is still the standard variety in Fiji. If a moderate crop of Badila is raised, say about forty tons per acre, the crop will stay erect and will not fall down or lodge before it is cut. With a very heavy crop of Badila, running from 60 to 70 tons per acre, a great deal of the cane will lodge and fall down when rainy or windy weather comes. This results in damage to the stools and breakage and deterioration of the cane. When harvested this heavy crop may have as much as 50 per cent of dead stalks in the field. This has resulted in the policy of raising the maximum profitable crop of about 40 tons per acre, as it actually gives a better return in millable cane and leaves the stools in good condition for ratooning.

For the plant crop, on the rich alluvial lands, it is therefore customary to apply no fertilizer. The medium and poorer lands give a good response to applications of coral sand at the rate of 5 to 10 tons per acre. It is also customary to use about 200 lbs. of sulfate of potash and 300 lbs. superphosphate per acre for the plant crop on these poorer soils.

The ratoons on both good and poor soils receive from 200 to 400 lbs. sulfate of ammonia per acre. The experience, over a number of years, has led the growers to expect an increase of 5 tons of cane per acre for each hundredweight of ammonium sulfate that is applied.

It was formerly customary to save all the trash in order to maintain the content of organic matter in the soil. This also returned an appreciable portion of the potash and phosphates which had been removed by the crop. On account of shortages of labor it has been necessary to abandon this practice on the plant and earlier ratoon crops. The trash is still saved on the last crop harvested before plowing.

As previously noted, the maximum profitable crop for Fiji conditions is about forty long tons per acre. This is commonly obtained from the best land on the plant crop. The plant crop on the poorer lands and the average ratoons will frequently be lower, probably yielding about twenty-five to thirty long tons per acre.

Formosa: The cane soils of Formosa are largely alluvial deposits derived from clay slates and to a smaller degree from sandstone. The resulting soils are in many cases of a heavy clay texture, though loams and clay loams are also found. The soils have nearly all been mapped according to the German system, which was adopted many years ago in Japan.

Considerable chemical work has been done on all the Formosa soils in order to establish any existing relationship between the classification and the composition of the soils. It is believed this work has developed information of considerable value in planning experimental work upon the fertilization of the cane land.

Extended investigations have been carried out in Formosa upon the reclamation of alkali land. Fortunately, the salts impregnating these soils are largely composed of the sulfates of sodium and magnesium, with smaller amounts of the chlorides of calcium, sodium, and magnesium. It has therefore been possible to reclaim these lands by very simple measures. A combination of drainage and irrigation has now converted some of these former saline areas into some of the most fertile soils in Formosa.

In order to determine the fertilizer requirements of the cane soils, field experiments have been carried on in thirty-four districts where different types of soil are located. In this work the attempt has been made by a study of the yields obtained by all possible fertilizer combinations and the analyses of the plants grown, to try and find the amounts of the different plant foods which the soils are capable of supplying. The general result of this experimental work has been to find that the soils of Formosa are more in need of nitrogen than of phosphoric acid or

potash. Some limited areas respond to phosphates, but very little return has been obtained from the application of potash.

One of the first studies undertaken in work upon fertilization in Formosa was the determination of the coefficient of availability of each of the constituents used in the commercial fertilizers. A great deal of work was done along this line and coefficients are now available for each of the commercial materials, when used under Formosan conditions.

The nitrogenous fertilizers most commonly used are ammonium sulfate and soya bean cakes. Some Chile saltpetre has been used, but there is considerable prejudice against its use because of possible loss from the heavy rains.

Green manuring is now considered one of the most valuable practices in Formosa. It has been calculated that a good green manuring crop will supply about 31 pounds of organic nitrogen per acre. It is now a common practice to grow a green cover crop at least once in three years.

It was formerly customary to burn all the cane trash, but latterly the attempt has been made to have the farmers return the trash to the soil. Where this practice has been followed, remarkable improvement has been noted. This is probably due to the great change which is made in the physical condition of the soil by working in the partly decomposed cane leaves. The Formosan soils are generally extremely heavy in texture. The cane ordinarily produces a poor root system in such land. After considerable organic matter is incorporated in this heavy soil, it becomes notably more loose and friable, and the resulting root system is far more extensive.

India: Sugar cane is grown in India upon a considerable variety of soils. The best cane lands are deep alluvial deposits, such as those which occur along the banks of the Ganges River. These soils are sandy loams to silt loams. Around Pusa, cane is grown upon a group of fine silty loams, which frequently may contain as much as 40 per cent of calcium carbonate. Going farther west, there are older alluvial soils which frequently contain undesirable amounts of soluble salts. In central India, there are many areas of heavy clay adobe, upon which cane is being grown.

In general, the soils of India are low in nitrogen and low in organic matter. This is not surprising when one reflects that these soils have been under cultivation for many hundreds of years. There has never been any general use of green manuring crops. Small amounts of cow manure are applied where it is available. A little oil cake has been used in some districts. A few of the more progressive commercial plantations are now purchasing ammonium sulfate. The native cultivators of India work their land to a very shallow depth, stirring the soil for a few inches with a small wooden plow. A field may be plowed in this way as much as ten or twenty times before the crop is finally put in. This is believed to cause considerable nitrogen fixation by azotifying organisms.

The cane yields obtained by these agricultural methods are very low. Exact figures are not readily available, but the yields are probably lower than those obtained in the other important cane sugar countries.

Philippines: There has been more work done on the soils of Negros than any other island of the Philippine group. This island also produces the greater portion of the cane crop. The soils of the western portion of Negros are derived from volcanic lavas, while in the eastern part of the island they have been formed from limestone.

It is only recently that fertilizers have been used in the Philippines. A number of series of experiments have been carried out and all have shown a notable increase from nitrogenous fertilizers. Very little gain has been obtained from either potash or phosphates. The principal nitrogenous fertilizer now employed is ammonium sulfate. Most of the mixed fertilizers which are being applied contain potash and phosphates, as well as nitrogen. These complete mixtures are being put on as crop insurance, in the absence of more extended experiments to show whether potash and phosphates may sometimes be required.

The best yields obtained in Negros will average about one and three-quarter tons of sugar per acre, for a twelve months crop.

Hawaii: The soils of the Hawaiian Islands are almost entirely volcanic. They are derived from a limited group of rocks, the so-called basaltic lavas. The characteristics of these rocks are: a comparatively low content of silica, a high content of iron and aluminum, and a considerable content of calcium and magnesium. The soils formed from these materials have largely been weathered in place and are nearly all residual soils. There are very limited areas of alluvial soils such as are commonly found in the great valleys of the mainland of the United States.

In texture, the Hawaiian soils tend towards the heavier types, loams, silt loams, clay loams, and clays. It should be explained that there are no true clays formed of potassium aluminum silicate, in the Island soils. The clay-like materials consist of the hydrated oxides of iron and aluminum. This gives a light soil of comparatively low specific gravity. The result is a spongy open texture which allows heavy rain to percolate through the soil with ease. There is very little tendency for such a soil to puddle or pack down. We never have any plow sole or hard pan formed in the Island fields.

It was formerly believed that exact deductions as to fertilizer requirements could be drawn from determinations of the plant food present in soils. Later work has shown the great variability of composition which exists in most soils. This has caused many investigators to feel that all such determinations are valueless. With the modern work that has been done in plant nutrition, we have come to feel that the one thing we can draw deductions from is an actual deficiency in any important limiting plant food.

Extensive work has been carried out at this Station upon the soils of the various experimental areas located in the different islands of the group. Part of these soils responded to either potash or phosphate fertilization, and part of them were evidently well supplied with both these constituents. The result of this work was to show that chemical determinations could indicate the soils which were most likely to require potash and phosphate fertilization. Such work is likely to be an excellent basis for the location of carefully planned field trials. The information given by such trials is probably the best basis for fertilizer practice.

Besides work on the composition of typical soils, extensive work has been carried on in Hawaii upon the effect of fertilizers upon the soil. No noticeable increase in alkalinity of the soil or harmful effect from the heavy applications of fertilizers have been detected. Investigations have also been made on the influence of slightly saline irrigation waters.

At the present time, the principal chemical investigation at this Station is a study of the factors underlying the occurrence of root rot. We are studying the relation of occasional accumulations of salt and the occurrence of high acidity to the susceptibility of varieties like Lahaina cane to root troubles.

In considering fertilizers for sugar cane in Hawaii, we may say there is practically always a response to nitrogenous fertilizers. The one exception to this statement is Grove Farm Plantation on Kauai. Owing to the cane area available on this plantation, it is customary to fallow the fields for about three years before replanting. The cover crop used is either the native wild legumes or pigeon peas. On the plant crop following this fallow period, no response is obtained to applications of nitrogen.

The amount of fertilizer used in the different districts in the Hawaiian group varies with the size of the crop that is ordinarily obtained. The field experiments of the Agricultural Department of this Station have helped to establish the profitable limits of fertilization in each section.

A large part of the plantations are using either complete fertilizers or mixtures which include several forms of nitrogen in combination with phosphoric acid. A portion of these plantations are only putting on potash and phosphates as a matter of insurance. We have one definite region which does give a response to potash in addition to nitrogen. This region is along the Hilo coast. Some of the fields at Ewa have shown a response to potash. There have been a few experiments in other districts where there appears to be a response to potash. There is, however, no uniform widespread need of potash.

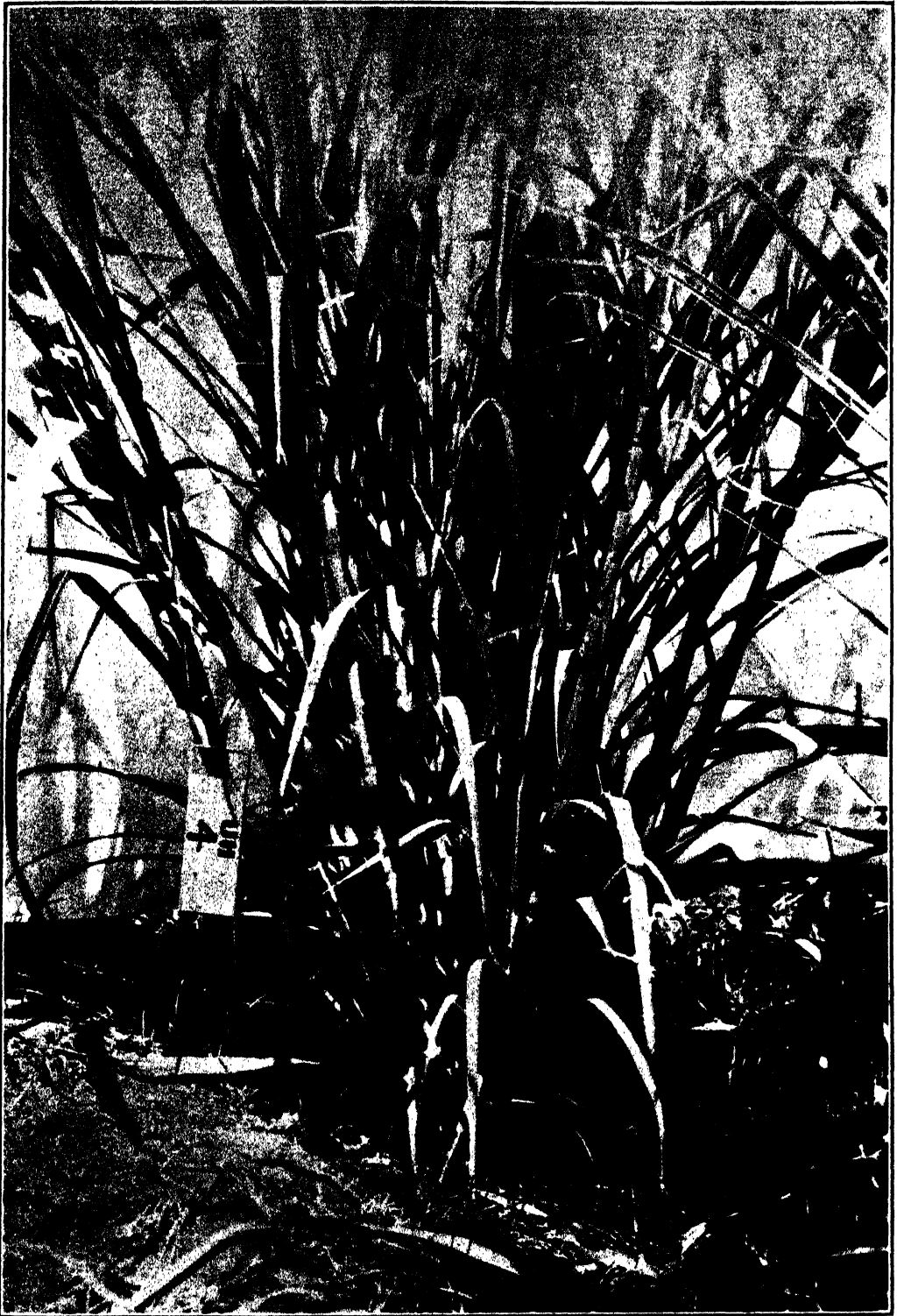
Experiments with phosphates have shown that there is a need for phosphates on a number of plantations. This is especially true of the upper fields in portions of Kauai, Maui, and Oahu.

The Hawaiian system of heavy fertilization is designed to obtain the maximum sugar production from the limited areas of land available for sugar planting. The Island soils appear well adapted to this agricultural practice. It may also be stated conservatively that there is no present evidence of any decrease in productivity from continuous cropping to sugar cane.

Uba Hybrids



U-D 65, A Hybrid of Uba and D 1135. Propagation of 1924.



U-H 4, A Hybrid of Uba and H 109. Propagation of 1924.

Lahaina Disease, Root-Rot or Plant Failure

By W. T. McGEORGE.

When the Lahaina variety first began to fail it was the general opinion that a pathogenic disease was making inroads upon this variety. Assuming a specific organism as the primary cause, the malady became known as Lahaina disease in view of the observations that the other varieties appeared to be more or less immune. Later, upon noting the same characteristics in diseased cane of other varieties in certain sections of the islands, a broader term, namely, root-rot, was adopted. The question now arises as to whether even this latter term is sufficiently broad to cover the problem which we now recognize in the failure of Lahaina and other varieties in certain sections of the islands and on a number of different soil types.

About two years ago the chemistry department undertook a study of the soil conditions associated with the infertility of some plantation soil types with special reference to those on which the Lahaina variety had failed and where other varieties were showing symptoms of so-called root-rot. In view of the presence of the most aggravated cases upon the Kauai uplands, which are composed mostly of acid types, the presence of acid salts of aluminum was suspected. The acid salts of this element have been found to be closely associated with the low fertility of many mainland soils and the problem is being intensively studied by a number of investigators at several experiment stations in the United States and Europe.

Our experiments have demonstrated beyond a doubt the toxicity of the salts of aluminum toward sugar cane and their presence in island soils. On the other hand their presence is limited to soils above a definite degree of hydrogen ion concentration or acidity. This latter point we have also proven beyond question.

Now, in casually surveying the past observations on the Lahaina failure, it was necessary to recognize the wide variety of soil types and environment in which root-rot prevails. Beginning with the Hilo-Olaa district, where Lahaina first failed, we find soil acidity with soluble iron and aluminum salts present associated with a deficiency of potash. At Honokaa we also have acid soils but fairly well supplied with both potash and phosphate. On Oahu we have root-rot on the Kaneohe soils of high acidity with deficiencies of both potash and phosphate. On the low, poorly drained fields of the irrigated plantations the soils are slightly acid or slightly alkaline, contain no acid salts of aluminum but show unmistakable evidence of saline accumulations from the irrigation water, the concentration of the soil solution depending upon such factors as seasonal rainfall, height of water table, etc. On Kauai we find root-rot in the upland soils which are high in acidity, deficient in phosphate and often in potash also. It may also not be amiss to mention a condition of H 109 on Oahu plantation diagnosed as root-rot which proved to be induced by a plant food deficiency. So much for soil types.

On reviewing the history of the disease in several of the island districts here wide variations are again noted. In the Hilo district the failure was rapid. On

the lower fields of the irrigated plantations the condition was accumulative and showed notable seasonal variation while on contiguous well drained fields Lahaina is still making good growth.

While fungi or other organisms have always been found present in the rotted roots by the pathologists, failure to discover a primary causal fungus led Dr. Lyon in 1915 to make the following statement:

This little experiment would seem to effectively eliminate senility and parasitic organisms as plausible explanations for the "Lahaina disease" and at the same time it indicates that the trouble lies in the soil. * * *

At this time further attempts to discover a toxic condition in the soil or a soil treatment which would correct this apparent infertility having failed, the problem was again taken up by the pathologists. In spite of some extremely intensive investigations, here again attempts to find a causal fungus failed, although the presence of associated fungi was clearly demonstrated. It is obvious from the above that we were forced to assume the association of the fungus as a secondary factor only; that some other agent resident in the soil was the primary factor, and that this later was predisposing the plant to the invasion of the fungus, in other words, lowering the vitality of the plant sufficient to permit the invasion of the organism. Reviewing the conditions previously mentioned we have to date evidence of a number of primary factors, namely, soluble salts of aluminum and ferrous iron, plant food deficiencies, saline accumulations which might act either as toxic agents or produce a variety of nutritional disturbances, and I might also safely add poor aeration or physical soil conditions.

The foregoing was the status of our investigations in April when the writer visited a number of experiment stations on the mainland where root-rot studies are being conducted. It is of interest to compare our observations with the progress of some of these stations particularly at Indiana and discuss their discoveries as applied to our own local problem.

Dr. G. N. Hoffer, at the Indiana Experiment Station, who has probably given this subject more intensive study than any other investigator, divides plant growth environment into three zones: health, susceptibility, and toxicity. The following will more clearly illustrate his method of classification:

Zone of Health:

Optimum environment for normal plant growth.

Zone of Susceptibility:*

Subtoxic concentrations of aluminum or other toxic agent.

Partial plant food deficiencies.

Association of fungus or other organism with these agents.

Zone of Toxicity:*

Toxic concentrations of aluminum or other toxic agent.

Notable deficiencies of plant food.

(The association of an organism is not necessary for plant failure in this zone although usually present.)

* It is my interpretation that he places no limit to the factors which may be present in the zones of susceptibility and toxicity. Poor physical condition of the soil and factors productive of abnormal nutritional disturbances might be included. Temperature, also, can be a factor.

Of the healthy zone no further explanation is necessary. It simply includes the environment under which the plant makes normal growth. Inhibiting factors are entirely absent or inactive.

In the zone of toxicity there is present sufficient concentration of aluminum (this one factor is given merely to typify a condition) to cause a serious stunting of the plant or death itself regardless of whether a fungus or other organism is present.

Within the zone of susceptibility most soil fertility problems arise. There is in this zone an environment productive of sufficient loss of plant vitality to predispose the plant to the invasion of many organisms. Taking aluminum again as an example, there will be present in the susceptible zone a concentration which of itself may not seriously stunt the growth of the plant, although its effect may be apparent. But in the presence of many fungi the organism, taking advantage of the lowered vitality of the plant, becomes, through invasion of the tissues, a secondary factor. The condition known as root-rot will follow. The same line of reasoning obtains for a plant food deficiency and Dr. Hoffer has demonstrated the above conclusively in many experiments. In simpler terms the fungus or secondary factor is "the straw that broke the camel's back."

Applying the above line of reasoning to our observations on sugar cane some very significant correlations are noted and a number of inconsistencies clarified.

Let us first consider Dr. Lyon's experiment in 1915, in which he transferred a sick Lahaina stool to our Experiment Station soil and obtained a complete recovery of the plant. In making this transfer he carried the secondary factor (the fungus) into the good soil in which the primary factor was absent. Leaving behind the primary factor the plant recovered on failure of the secondary factor to "play its role" effectively in the absence of the primary predisposing agent. This same line of reasoning applies in the recent experiments of Mr. Lee in which he obtained renewed growth on transferring "sick" stools from Puunene fields to the Experiment Station soil.

Now let us refer in the same manner to Mr. Carpenter's investigation of the pythium fungus. On sterilizing the soil, thereby removing the secondary factor (the fungus), he improved plant growth. That is, the primary factor (toxic agent) being present only in subtoxic concentration, he thus obtained better growth, although not absolutely normal in all cases. On reinoculating the sterilized "sick" soil, thereby obtaining again the association of both primary and secondary factors, he was able to produce the root-rot as it existed in the soil originally. He also improved root growth in pots by the use of Qua Sul and copper sulphate. It is entirely fair to assume here also that the improved growth obtained by the above treatments was due to their fungicidal properties and control of the secondary factor. Inability to completely control the fungus by the above fungicides in the field, as was possible in pots, will explain the failure of the above on a field scale. Mr. Carpenter's work clearly demonstrates the *association* of the pythium type fungus with the so-called root-rot.

Merely as illustrating the point at issue we may even proceed further in applying Dr. Hoffer's classification. For example, in eye-spot there are certain climatic factors which predispose the cane to invasion of the fungus. In view

of this essential climatic environment is it not fair to classify the climatic factor as primary and in a like manner the red stripe disease which attacks primarily the Tip canes. Is it not fair to assume some inherent characteristic of the variety as predisposing these canes to invasion? While these allusions are far removed from the chemical factors which we find predisposing the cane to so-called root-rot they well illustrate the logical line of reasoning which Dr. Hoffer is applying so successfully in his root-rot investigations on corn.

In his physiological examinations he has noted certain characteristic differences between normal corn plants and those which have become severely root-rotted. Namely, that the vascular plate tissues in the nodes of the stalk are discolored and in various stages of disintegration. Qualitative and quantitative tests for iron and aluminum have shown abnormal accumulations of these elements at the nodal joints. This accumulation, usually, is also associated with a stunted condition when the inhibiting agent is other than soluble iron and aluminum salts in the soil.

In examining cane stalks grown on acid soils at Olaa and Honokaa we have found these same characteristics in sugar cane. Also in examining the short internodal winter growth of cane stalks we have found these nodal accumulations.

Dr. Hoffer believes that this disintegration of the nodal vascular plate tissues precedes the rotting of the plant roots. In other words, the channels of food transmission are cut off, resulting in a general failure of the plant. Root-rot thus becomes a more complex problem and one of plant failure rather than root-rot alone.

Further facts which might throw some light upon the comparative resistance of cane varieties were gathered at the Rhode Island Experiment Station. It has been suspected that there might be some variation in the nutritional requirements of Lahaina and other varieties as well as differences in their foraging properties and powers of selection or rejection of mineral salts in the soil solution. The Rhode Island Station in studying the root-rot problem has included a wide variety of crops. They have found that the carrot has a remarkably constant mineral composition regardless of the soil environment under which it is grown. Its inherent powers of resistance are also high. On the other hand, lettuce, onions and some other crops included in their studies show a wide variation in mineral composition when grown under different soil conditions and a low degree of resistance. In other words, the selective power of the plant or its foraging power appear to be closely related to degree of resistance.

SUMMARY

The above is offered as a comparison of our root-rot problem with the results being obtained in similar investigations on the mainland. The complex nature of the problem becomes more evident as progress is made and appears as one of greater breadth than implied in the term root-rot. We often note characteristic symptoms in the tops as well as the roots. These include premature dying of the lower leaves and their greater tenacity to the stalk. The preliminary symptoms of malnutrition are also evident, as are also indications of a moisture

deficiency. These include stunted top growth, less stooling and dying or curling of the leaf tips. Our problem is therefore one of general plant failure under a number of conditions of infertility. Lahaina cane being a susceptible variety adapted to a narrow range of conditions has prompted the term "Lahaina disease," but it now becomes evident that the failure of this variety is only one phase of a larger problem.

Prevention of Mold in Polariscopes*

By HERBERT S. WALKER.

One of the minor problems encountered in a tropical sugar factory is the difficulty of keeping polariscopes in good condition. During damp weather the Nicol prisms and quartz wedges become infected with a mold growth which, unless removed, etches into their polished surfaces and eventually ruins them for accurate work.

Heretofore the only remedy has been to take the instrument apart occasionally and wipe off the optical parts. This is a rather troublesome operation since it generally means readjustment of the scale, and, unless done by an expert, may cause serious damage to the delicate prisms.

During the past season we have been experimenting with thymol as a mold preventive, with very promising results. The polariscopes are disassembled, cleaned and a few crystals of thymol inserted in the compartments at each end of the polarizing and analyzing Nicols and in the bottom of the brass case which covers the wedge mechanism. The polariscopes at two of our centrals were thus treated early this season and have stood for more than six months without any sign of mold growth, although it had formerly been necessary at one of these factories to clean off the prisms every two weeks. Polariscopes not treated with thymol all showed some damage from mold when opened up at the end of the grinding season.

Since thymol is slowly volatile, one treatment will not last indefinitely, but as long as the odor persists the instrument is probably safe. Present indications are that the antiseptic will not have to be renewed more than once or twice a year.

Some Sugar Cane Growth Measurements

By H. K. STENDER.

[In 1922, after reading of the exceptional cane growth secured by Dr. Mario Calvino, and associates, at the Cuban Experiment Station, from widely spaced single-eye plants of sugar cane, started first in small boxes and afterwards placed

* Sugar News, Vol. 5, No. 8.

in deep holes, well nurtured and amply supplied with water, we decided to conduct a similar test in the forced feeding of cane. We used some selected progenies to have whatever advantage of yield that this might lend.

The detailed yields were reported in the *Record* for July, 1924, by A. D. Shamel.

In order to study the seasonal growth of cane independently of irregularities and deficiencies in nitrogen and irrigation, we started in August, 1922, systematic

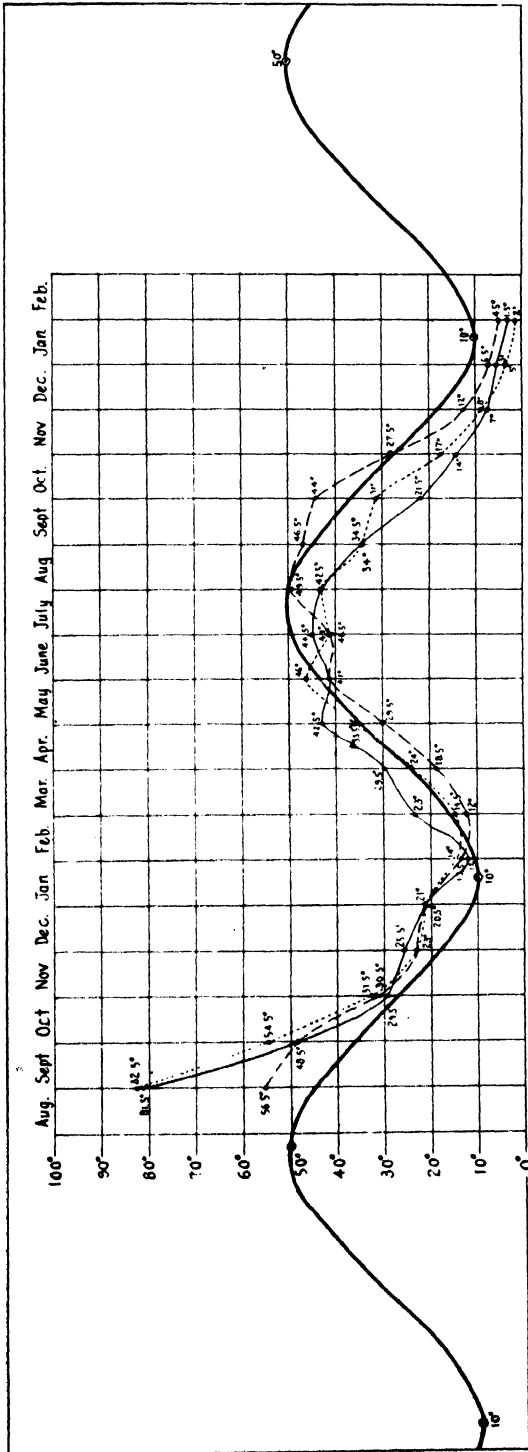


Fig. 1. The heavy line extending across the diagram is the curve of potential cane growth suggested in the 1923 annual report of the Experiment Station. (It is based on the hours of daylight offset by twenty-eight days.) Plotted against that curve are the average growth measurements from six representative stalks of cane grown under prime conditions of fertilization and irrigation, so that the growth would reflect that difference due to heat and light and the age of the cane. The measurements are shown in three ways: length of stalk, volume of stalk, and weight of stalk (the last two were taken after harvesting). The solid line (—) represents weight, the dotted line (.....) volume, the dashes (---) elongation. It will be noted that the weight curve shows 81.5 growth degrees for August, 1922, instead of the theoretical 50; but in August, 1923, a second season growth of 42.5°. In general, the second season growth falls much below the first season growth, giving additional evidence in favor of the idea of producing two crops of cane in three years.

measurements of a number of stalks in this plot. The details of this phase of the work were handled by H. K. Stender, under the direction of J. A. Verret, and are recorded here by notes, diagrams, and photographs.

In order to study the relationship of measured cane growth to the curve of potential cane growth proposed and illustrated in the annual report of the Experiment Station for 1923, whereby July growth was assumed to be five times that of January growth, Mr. Stender has reduced his measurements to a percentage growth-degree basis and has plotted them upon the proposed curve of potential cane growth as shown on Fig. 1, page 473. From his diagram we see that the theoretical curve does not exaggerate the difference in seasonal growth actually secured in this cane, but in fact falls short of it.—H. P. A.]

Location: The plot is located on the Experiment Station grounds in the west section of Makiki Field 7.

Planting: Single-eye, three-joint cuttings (two eyes having been gouged out) of the various progenies of H 109 were planted in small germinating boxes on April 8, 1922. On May 25, 1922, the young plants were transplanted to holes that had been dug in Field 7. These holes were $1\frac{1}{2}$ ft. x $1\frac{1}{2}$ ft. square, by $1\frac{1}{2}$ ft. deep, and spaced 5 feet from center to center.

Irrigation: The irrigation of the cane in this plot was done with a garden hose. For the first month and a half, May 26 to July 6, 1922, a one-inch irrigation was applied semi-weekly; for one month after this, July 10 to August 4, 1922, a two-inch irrigation was applied semi-weekly, then for a period of nine months, August 8, 1922, to May 8, 1923, four inches was applied semi-weekly. Rain was taken into consideration during the winter months in that no water was applied whenever the rainfall was sufficient to keep the ground thoroughly moist, and at times water was applied to make up the difference whenever the rainfall was not sufficient to amount to a four-inch irrigation. For the remainder of the growing time, a period of seven months, a six-inch irrigation was applied semi-weekly. The idea was to keep the ground thoroughly moist so that at no time would the cane suffer from a shortage of moisture.

A detailed record of irrigation is recorded below:

Cane planted 5/25/22.

5/26/22 to 7/6/22 1" irrigation semi-weekly.

7/10/22 to 8/4/22 2" irrigation semi-weekly.

8/ 8/22 to 5/8/23 4" irrigation semi-weekly. Rain considered.

5/12/23 to 12/6/23 6" irrigation semi-weekly.

Cane harvested March 17, 1924.

At the above rate of irrigation it is evident that water was eliminated as being a possible limiting factor in the growth of the cane.

Fertilization: Starting with June 12, 1922, and at regular monthly intervals thereafter, up to and including September 12, 1923; applications of a mixture of nitrate of soda and sulphate of ammonia were applied at the rate of 100 pounds of nitrogen per acre per month. This was made up as follows: $2\frac{1}{2}$ oz. of N. S. and $2\frac{1}{2}$ oz. of A. S. or a total of 5 oz. of the mixture per hole. In addition to this, a mixture of stable manure and decaying trash was applied at three dif-

ferent intervals while the cane was still quite young. The first application was applied on July 24, 1922, at the rate of 3 bucketfuls per hole. The two subsequent applications were applied on August 10, 1922, and September 1, 1922, respectively, at the same rate, 3 bucketfuls per hole, for each application, making a total of 9 bucketfuls per hole.

At the above rate of fertilization it is also evident that fertilizer was eliminated as being a possible limiting factor.

Environment: This factor was largely eliminated as all the stools selected for growth measurements were inside stools and located within a small area, and yet each stool spaced enough apart to insure heavy growth.

Temperature: Fertilizer, water and environment having been reduced to a minimum as possible limiting factors, seasonal differences in growth may be attributed almost entirely to the influence of temperature and daylight.

Growth Measurements: Mr. Shamel in his article, *The Performance Records of Some Individual Sugar Cane Stools*, writes as follows: "Growth Measurements: Systematic growth measurements were carried on with stalks of selected stools in order to show the rate of growth of the plants during the different seasons throughout the course of this experiment."

Unfortunately, the idea of making growth measurements in this cane did not occur until quite some time after the puka planting experiment had started. The experiment started in April, 1922, and it was not until August 15, 1922, when the first growth measurements were made. Practically three months of the best growing time was not recorded. Had this been done, a more complete growth curve could have been constructed showing very accurate relationship between first season and second season growths for cane planted at that particular time. About 15 stools in this small area having maximum controlled conditions, excepting temperature and light, were selected for growth studies. One stick in each stool was used upon which measurements were to be made. During the course of the experiment many of them were eliminated due to various conditions that had arisen, such as: having been blown over, broken, attacked by rats, borers, termites, etc. At the end of the experiment there remained only six stalks upon which growth measurements had been made throughout the whole time, from planting to harvesting. Of these six, three stalks tasseled three months before harvesting and three stalks kept on growing at a very slow rate. An average of these six stalks was taken and used to compare with the temperature curve.

Method of Procedure: Two small stakes were driven into the ground, one on each side of a stool in which a stalk was to be measured. They were driven so that the tops were very close to the ground and quite level. A stick placed in a horizontal position on the tops of these two stakes gave a permanent level from which measurements could be made. From the intersection of the bottom of this stick and the cane stalk a measurement was made up to the last appearing joint triangle (see Fig. 2). From then on a new measurement was made every time a new joint triangle appeared, and every time a measurement was made the date was marked on the joint triangle, India ink being used.

After the leaves fell off it was an easy matter to trace back the dates from the record and identify the joint formed by any particular leaf. In this way

the rate of joint formation and cane growth is secured for any unit of time. The data were recorded as follows:

Stalk No.	Days	Date	Length	Days	Date	Length	Days	Date	Length
35	8/14	.96	4	8/18	1.14	4	8/22	1.37
37	8/14	1.00	4	8/18	1.18	5	8/23	1.46
40	8/14	1.30	3	8/17	1.48	4	8/21	1.67

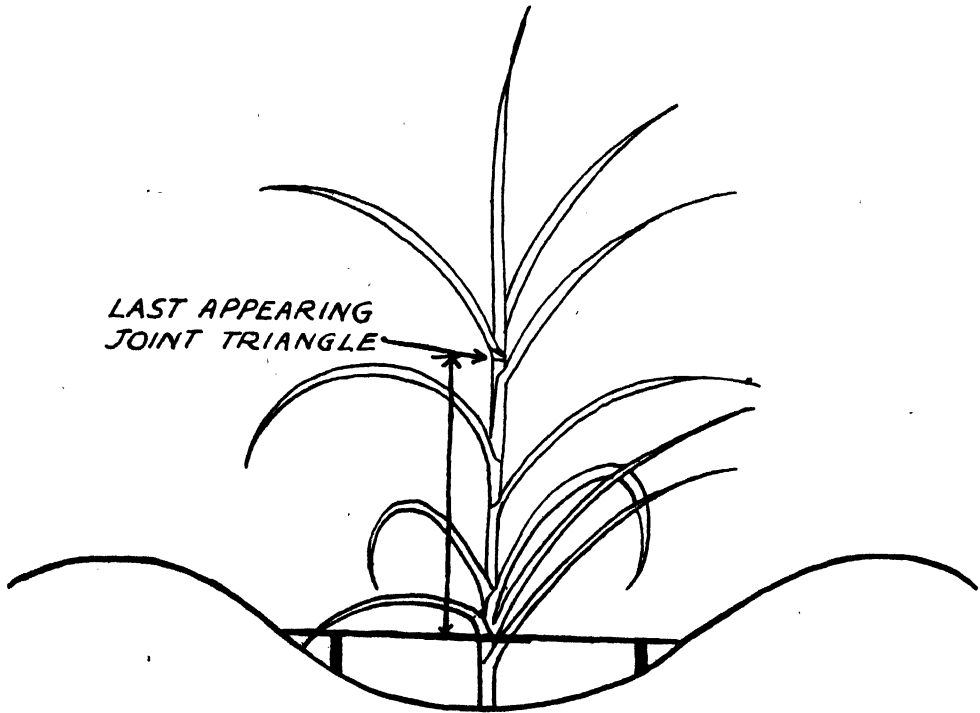


Fig. 2. Method of making growth measurements.

In order to keep up this record it was an almost daily routine of observations so that as soon as new joint triangles appeared the canes were measured and data recorded. From this data sheet, a growth curve can be constructed showing the rate of growth (elongation only) per month. This is shown in Fig. 3.

When the plot was harvested great care was taken not to break any of the stalks upon which growth measurements had been made. On each joint of each stick the date of the appearance of its corresponding joint triangle was recorded. In this way the growth for any particular period of time could be visualized.

Diameter measurements were then made on each joint and an average diameter arrived at for each month's growth. From the length per month and diameter figure for that month, volume per month was calculated. This was done for each of the six stalks and then averaged, and the average volume per month arrived at. The volume curve is shown in Fig. 4.

From the Weather Bureau of the U. S. Department of Agriculture a complete record of the average monthly temperatures covering the entire period of time during which this experiment was in progress was obtained and plotted. This is shown in Fig. 5.

Placing all of the above curves on one sheet we can picture the effect of temperature on cane growth. See Fig. 6.

Illustrations of some individual stalks are given.

Plate 1 shows the growing portion of Stalk No. 35 with dates marked on the joint triangles indicating the time when these joint triangles first appeared and measurements made. Each measurement was made from the last appearing joint triangle down to a marked point somewhere on the stalk below, which was assumed to be constant. It is not difficult to understand how, after the dry leaves have fallen off, the corresponding dates can be traced back from the recorded data and any particular joint located and marked. In this way a determination of just what section of the stalk was formed in any particular month was made possible, and a natural graph was made by cutting the stalk into sections determined by the dates on the joints and placing these sections vertically upon a horizontal plane as shown in Plate 4.

Plate 2 shows the stripped growing portion of the same stalk (Stalk No. 35) with dates marked on each joint. These dates were transposed from the leaves, and then from the recorded data dates following these were marked along the remainder of the stalk.

Plate 3 shows the entire stalk (Stalk No. 35) with monthly sections marked off. These sections were cut at the points marked and the natural graph shown in Plate 4 was made.

In studying the above photographs it becomes evident that a great saving in time, with less dead cane and very little difference in yield, would have been effected had this experiment been cut at 18 months.

Four illustrations of Stalk No. 36, giving the same information are also shown, and four others pertaining to Stalk No. 40. From these one may study the small differences of individual stalks, as well as the general similarity due to seasonal influences.

Plate 13 shows a stalk of cane harvested from this puka planting experiment upon which growth measurements had been made. This stalk is 23 feet long, not measuring the leaf portion.

Diameter Studies: In conjunction with the above investigations some studies in diameter measurements were carried on, the object being to determine whether or not cane increased or decreased in diameter after the dry leaves had fallen off. A micrometer caliper was used in this work and fairly accurate figures were obtained. This work was carried on as follows:

With a micrometer caliper the long and short diameters of each joint of each of the six stalks mentioned above were measured, starting from the dead leaf portion and going down along the stalk a year's growth, starting with the section of the stalk formed in August, 1923, and going back to the section formed in August, 1922.

The long and short diameters were averaged for each joint and the joint diameters were averaged for each month. In this way the curve shown as a smooth line in Fig. 7 was plotted. Six months later the diameters of these same canes were measured at exactly the same points where they had been measured previously. In the same way the average monthly joint diameters were arrived at and plotted. This is shown as a broken line in Fig. 7.

By studying the curves it will be noted that the differences in diameter one way or the other are so small as to be within experimental error. Hence it is to be concluded that after the dry leaves fall off there is no increase or decrease in diameter.

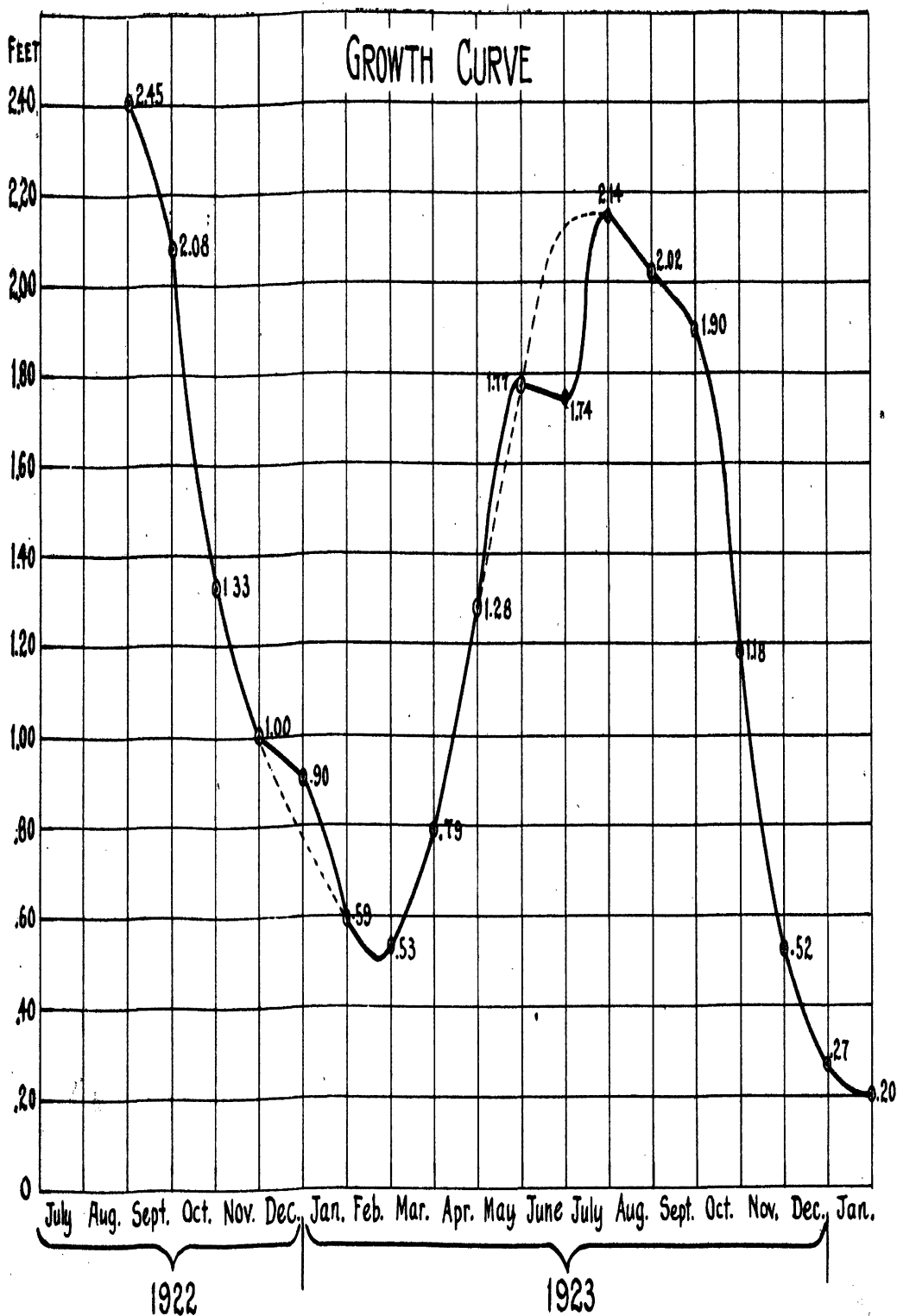


Fig. 3. Showing length per month in lineal feet. Average of six stalks of H 109 cane; planted April 8, 1922, first measurements made August 15, 1922; harvested March 17, 1924.

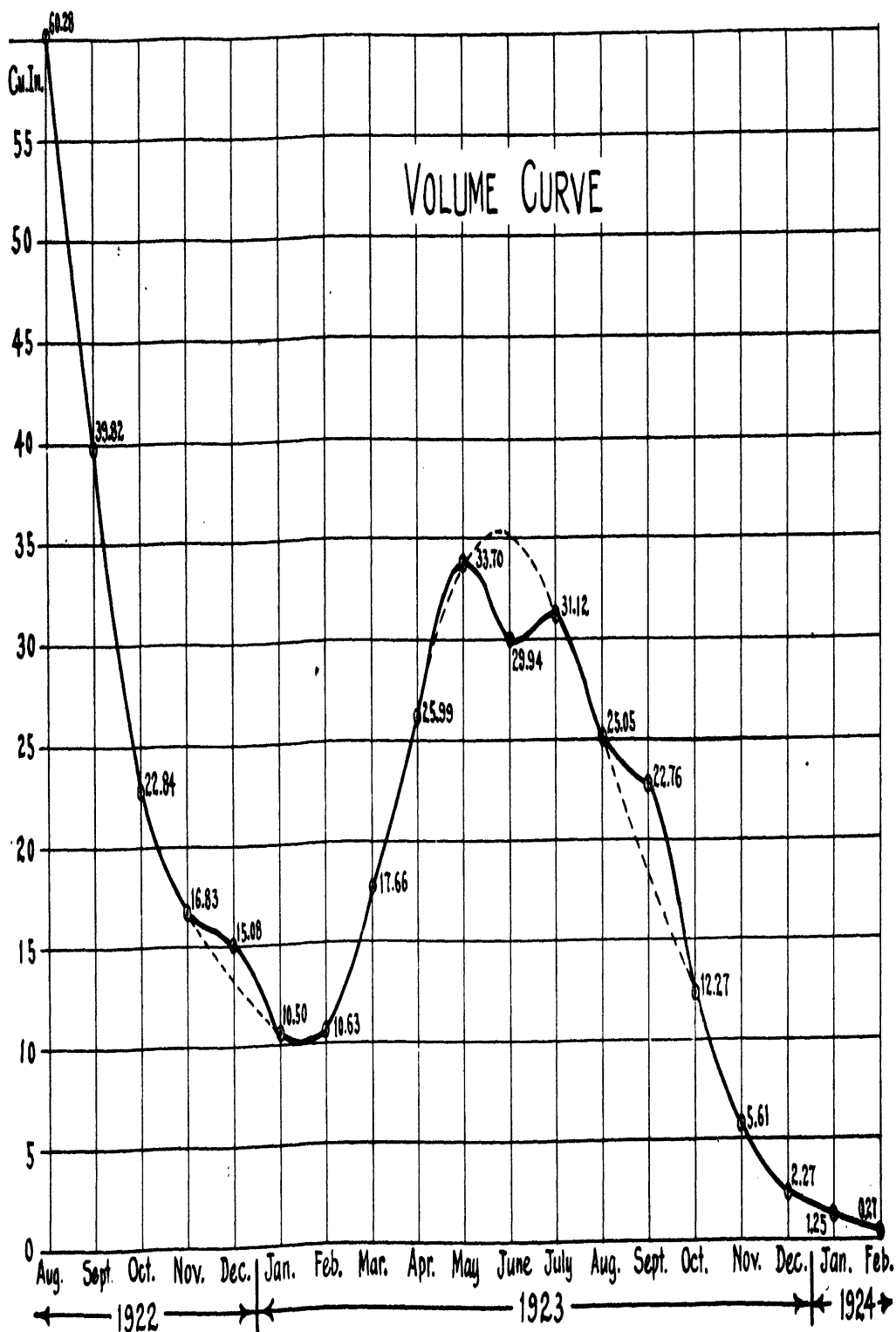


Fig. 4. Showing the volume of cane produced per month in cubic inches; average of six stalks of H 109 cane. Volume calculated from data secured on circumferences and lengths.

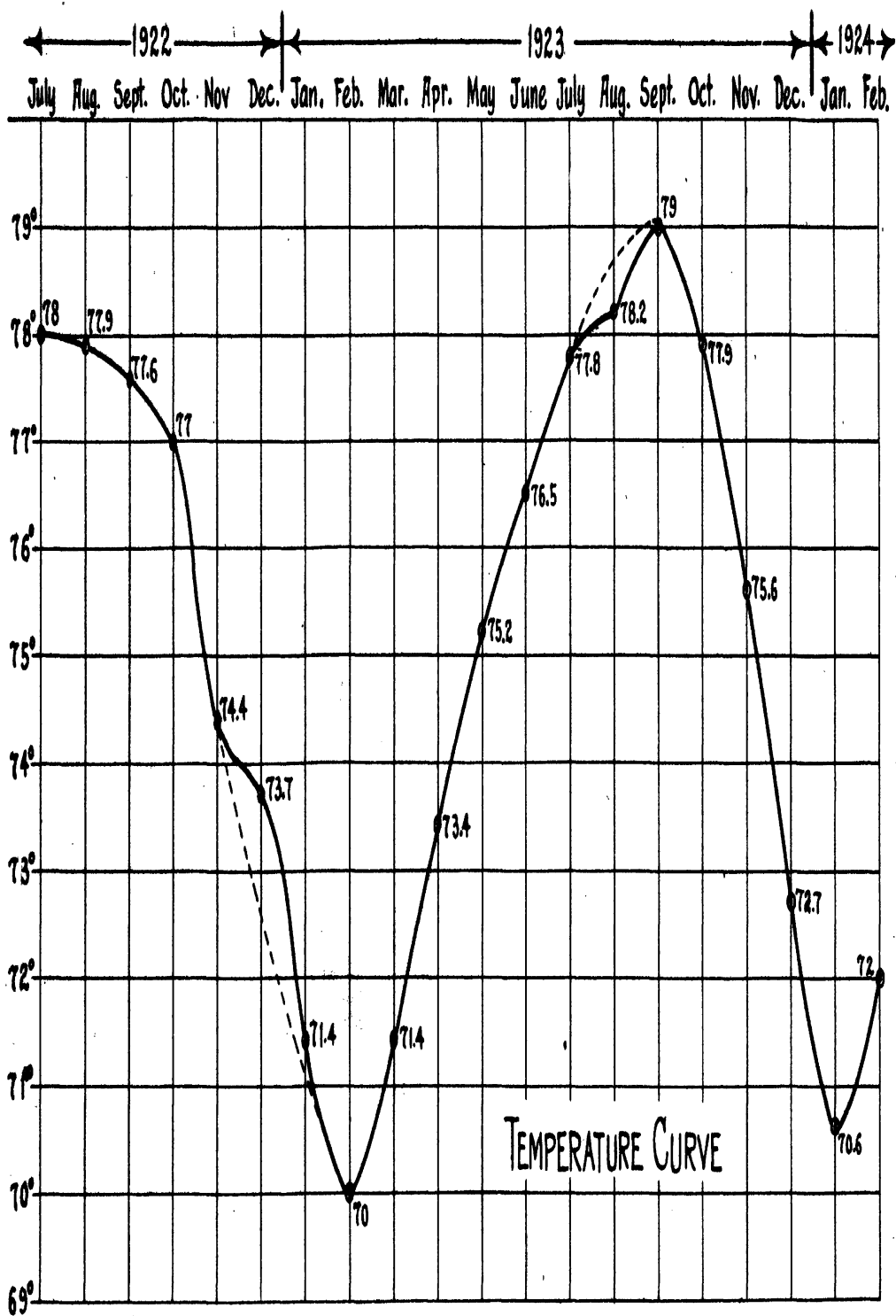


Fig. 5. Average monthly temperatures from July, 1922, to February, 1924. Taken from the Monthly Meteorological Summary of the Weather Bureau of the U. S. Department of Agriculture.

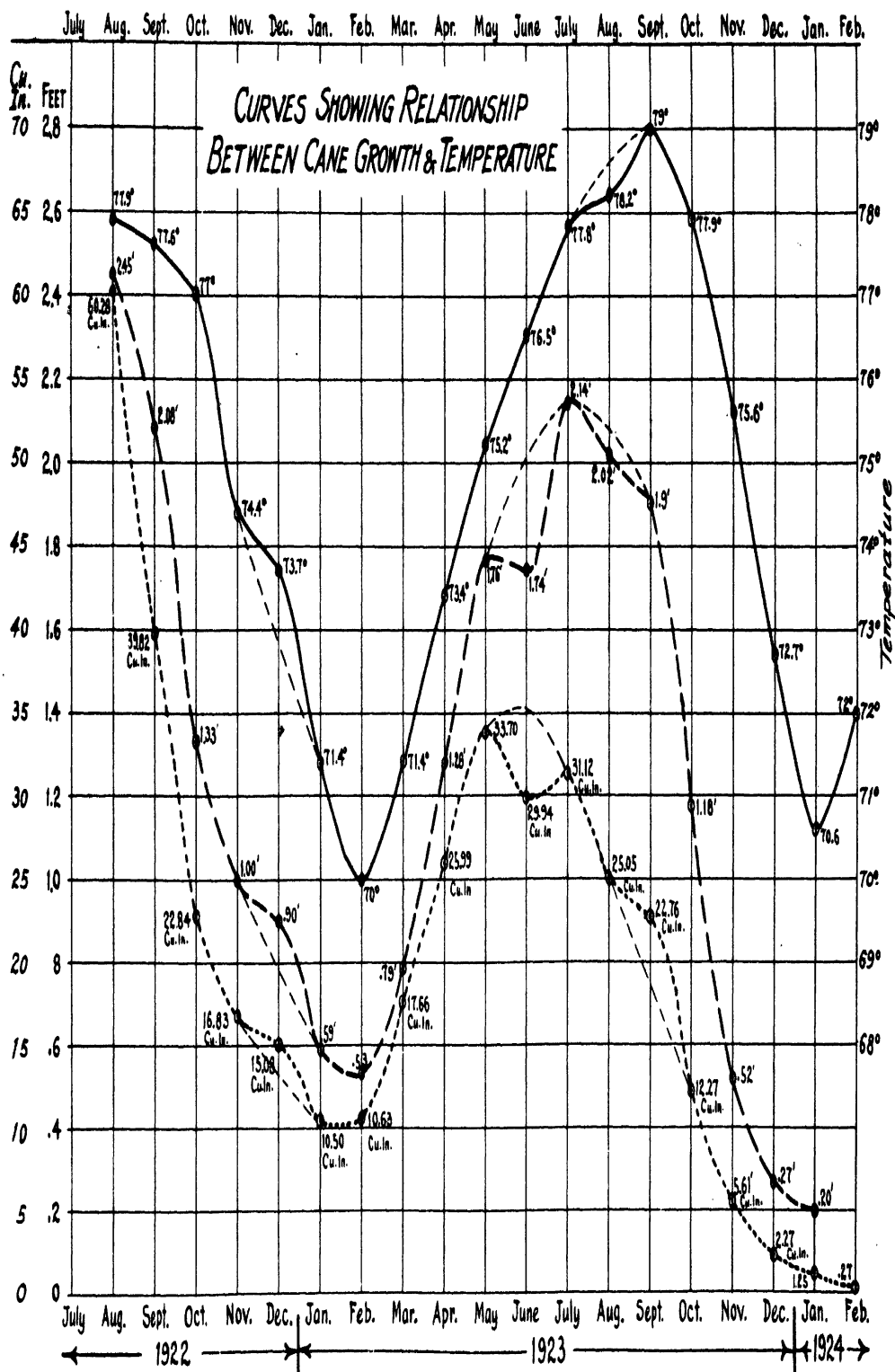


Fig. 6. The solid line (—) is the temperature curve shown in Fig. 5. The broken line (---) is the growth curve shown in Fig. 3, and the dotted line (.....) is the volume curve shown in Fig. 4. These curves are plotted here so as to show the effect

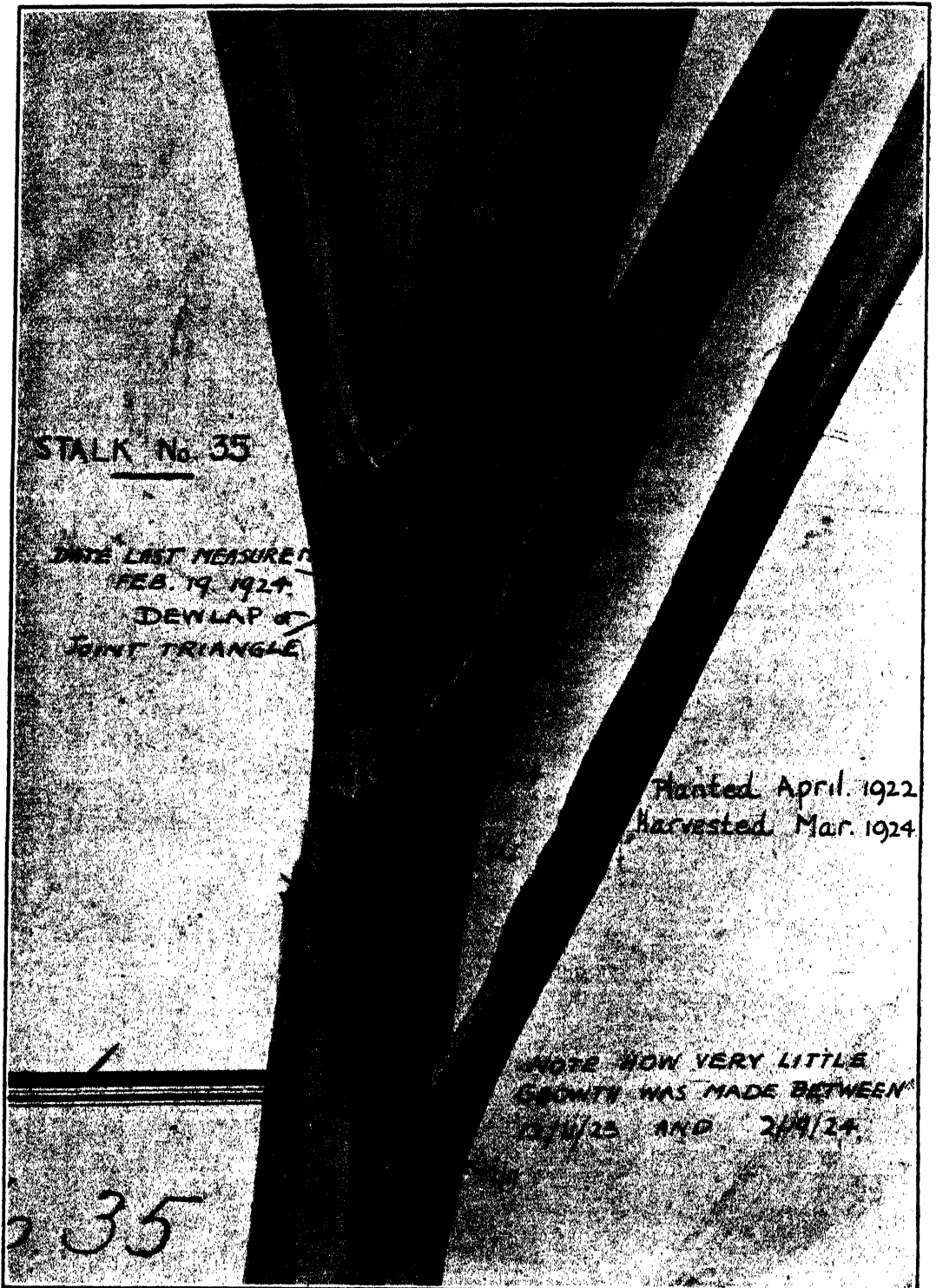


Plate 1. The top of Stalk No. 35, showing that growth had almost ceased at the end of the two-year period.

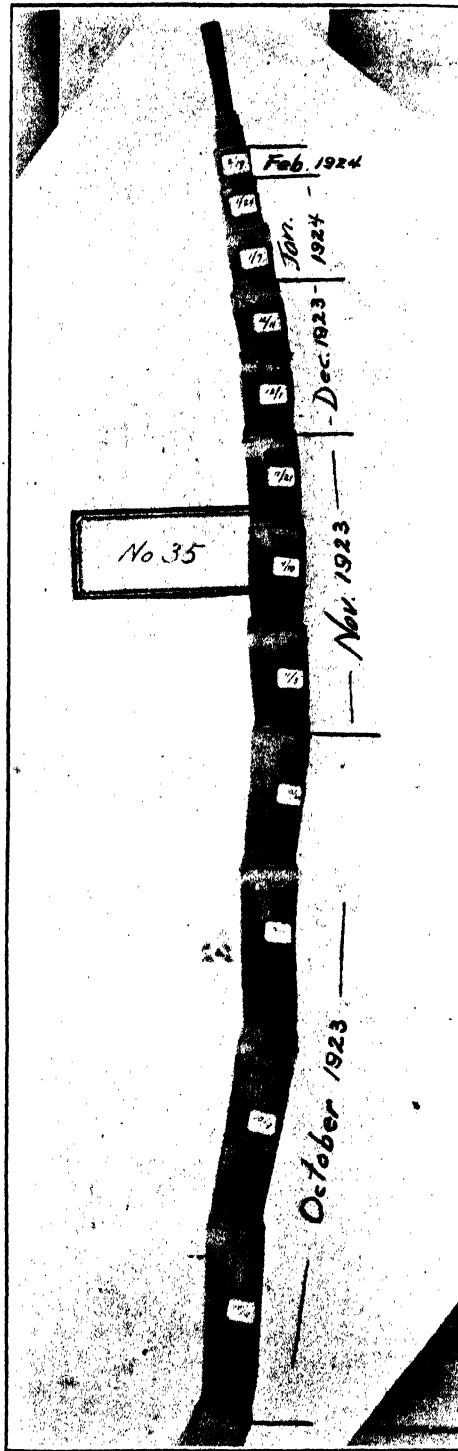


Plate 2. The top of Stalk No. 35, stripped of its leaves to show the slow rate of joint formation during the second winter of its growth.

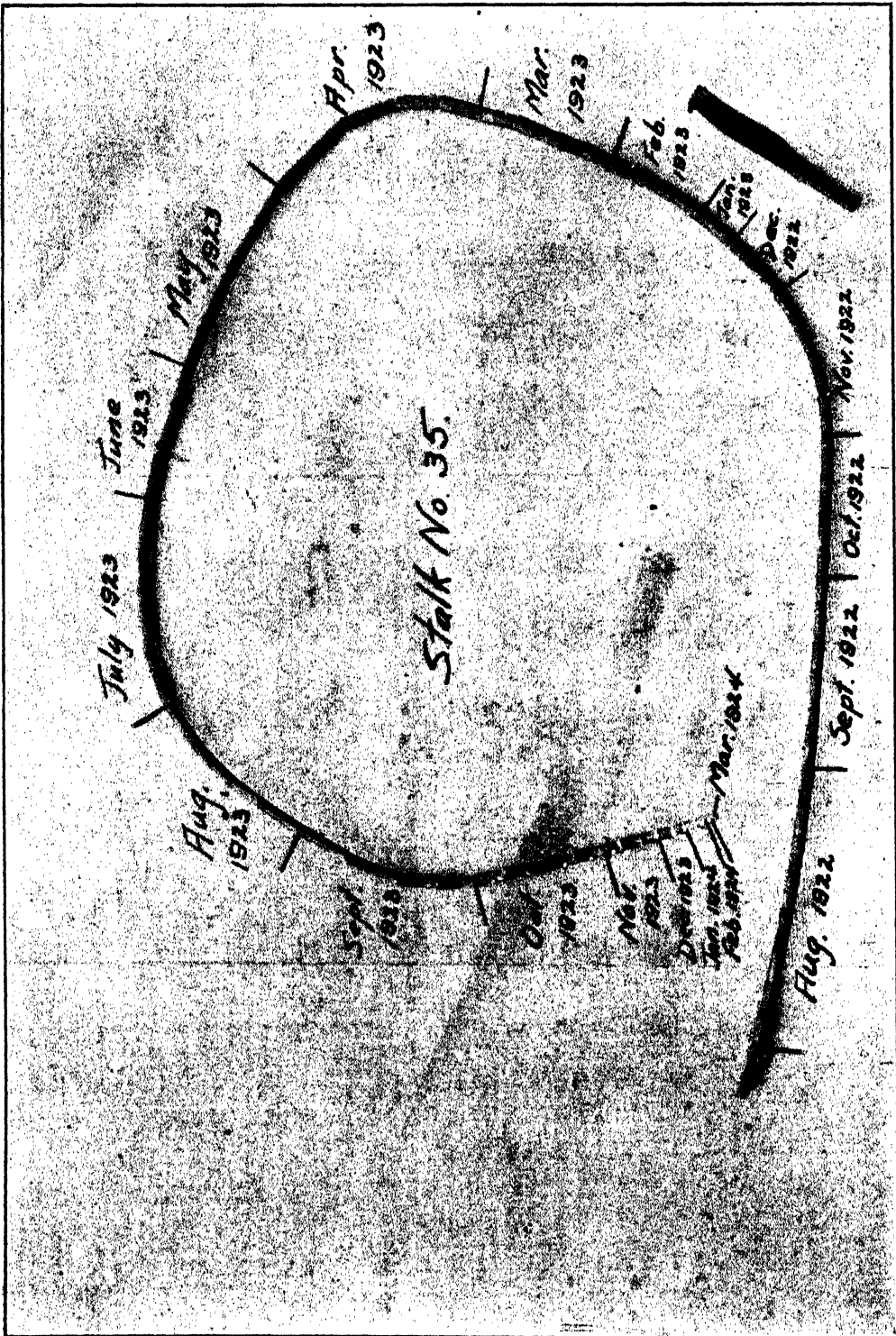


Plate 3. Stalk No. 35, marked to show the monthly growth.

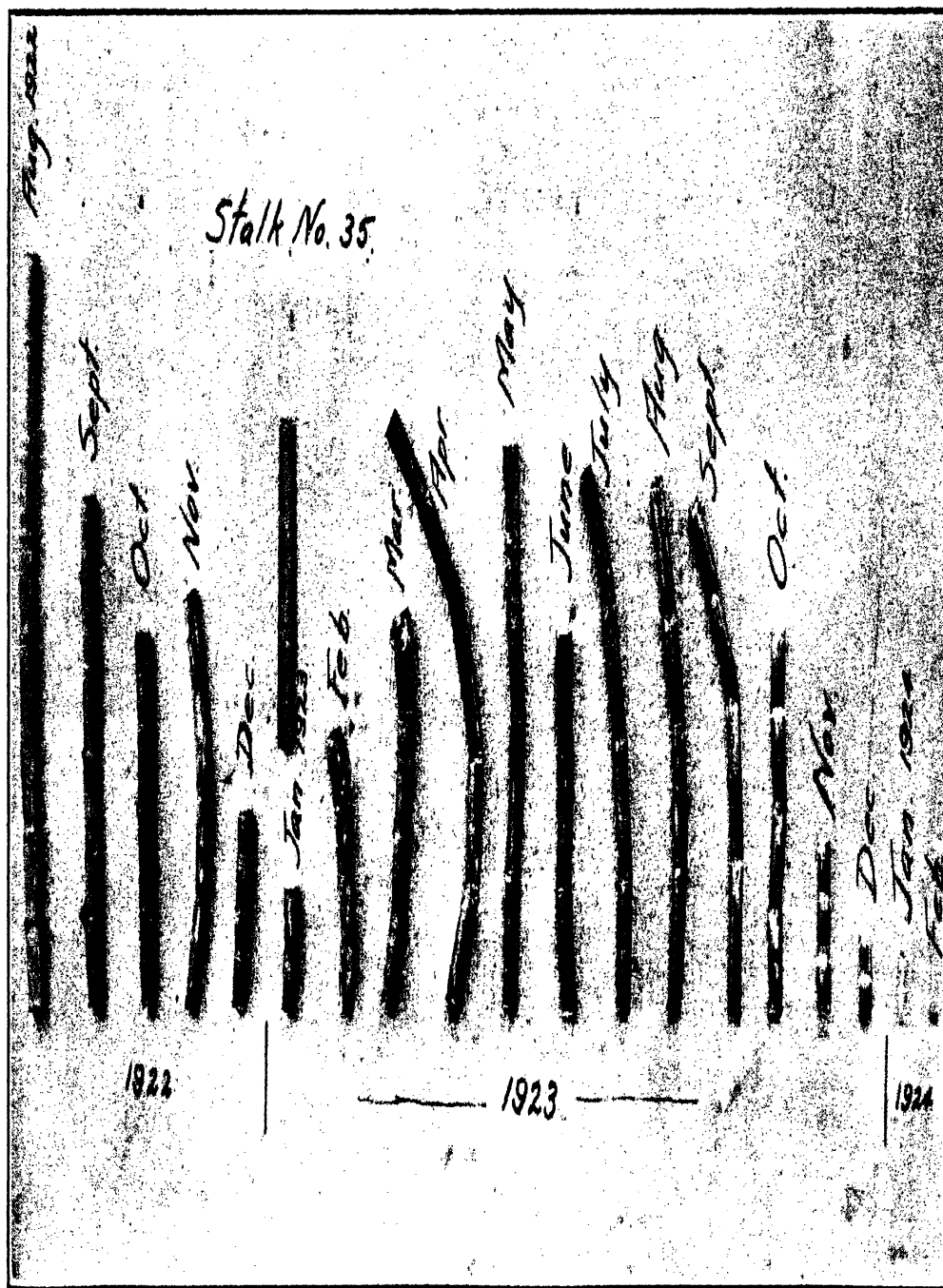


Plate 4. Stalk No. 35, as shown in the previous picture, is here cut into sections so as to get a better comparison of the growth that took place from month to month.

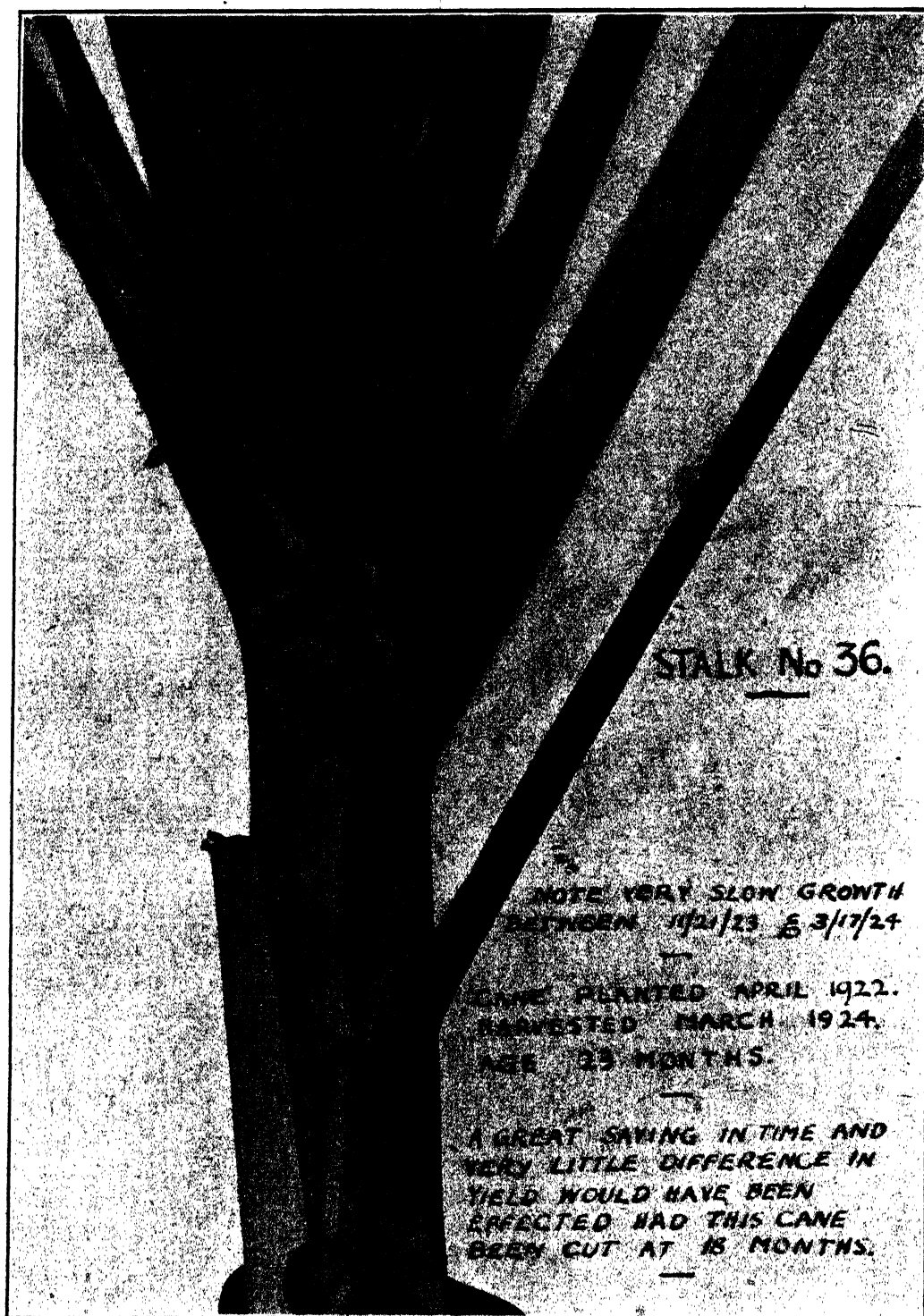


Plate 5. This photograph and the three that follow show the same views of Stalk No. 36 as have already been shown of Stalk No. 35, in order that the general similarity of growth can be noted together with the minor variations due to individual stalk differences.

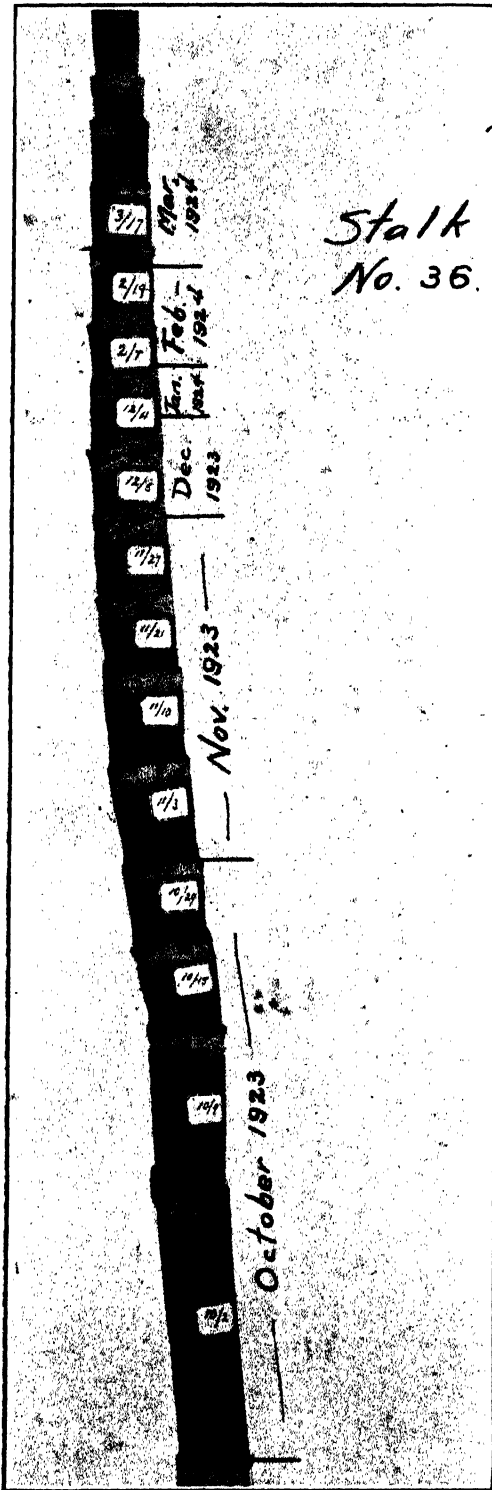


Plate 6. Stalk No. 36. Compare with similar pictures of Stalks Nos. 35 and 40.

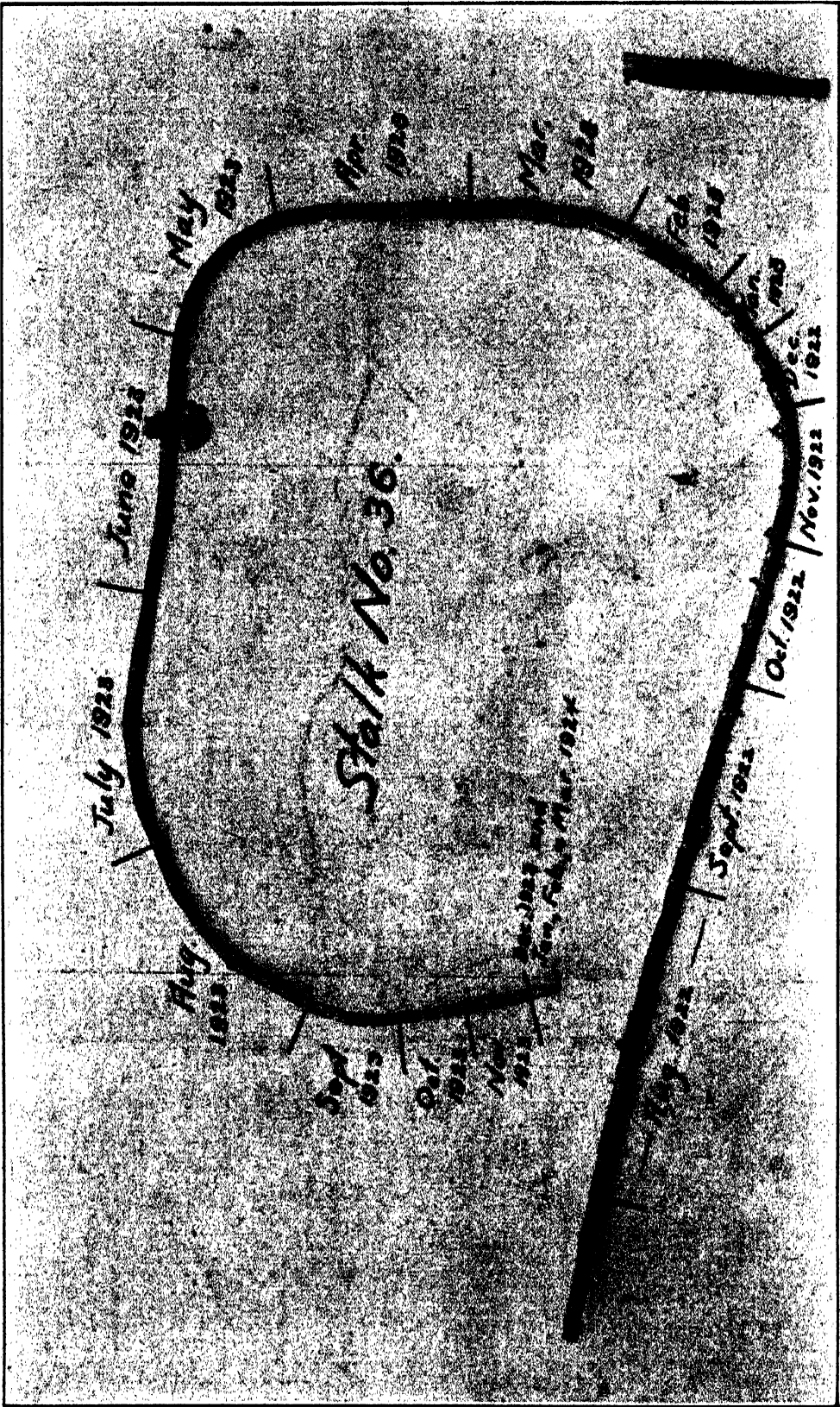


Plate 7. Stalk No. 36. Compare with similar pictures of Stalks Nos. 35 and 40.

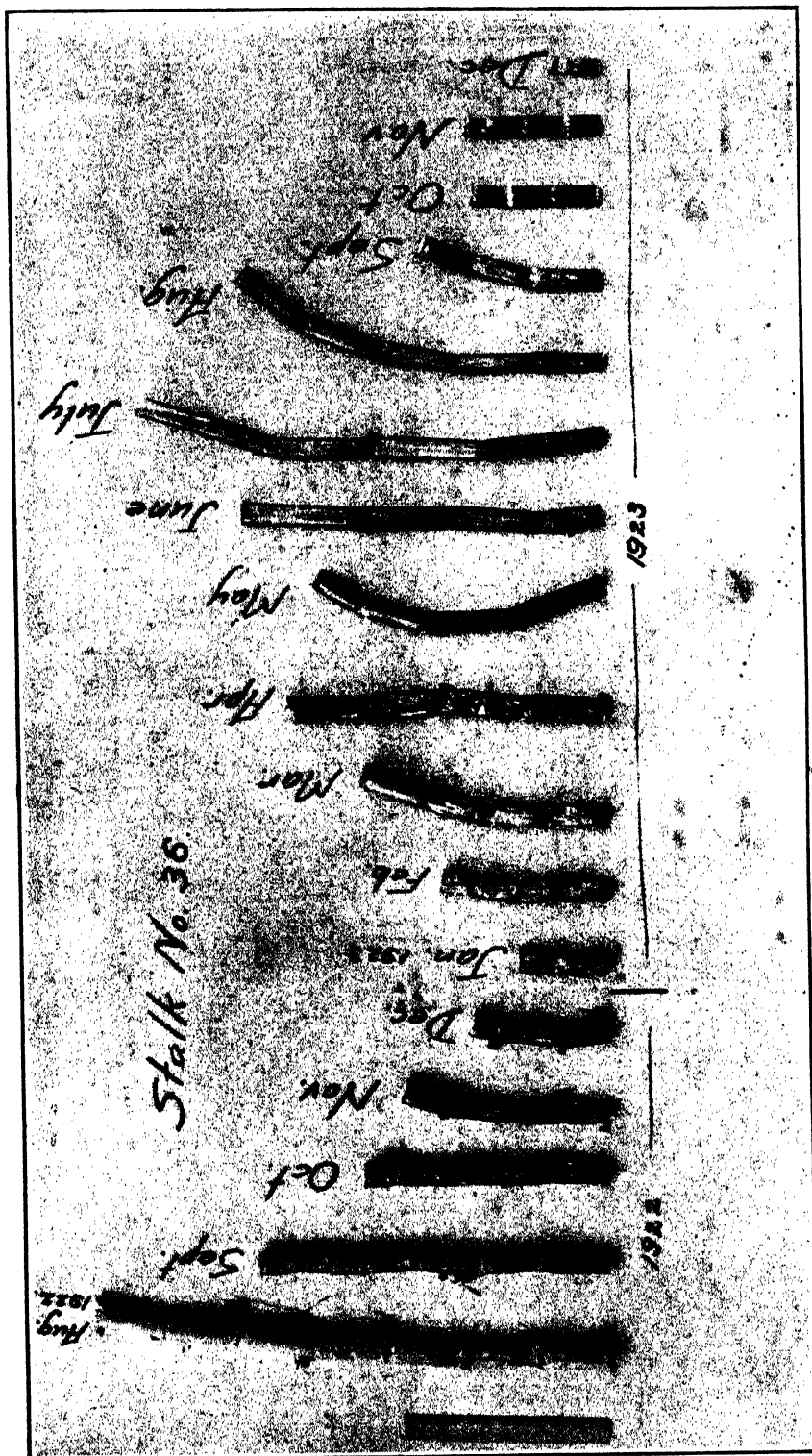


Plate 8. Stalk No. 36. Compare with similar pictures of Stalks Nos. 35 and 40.

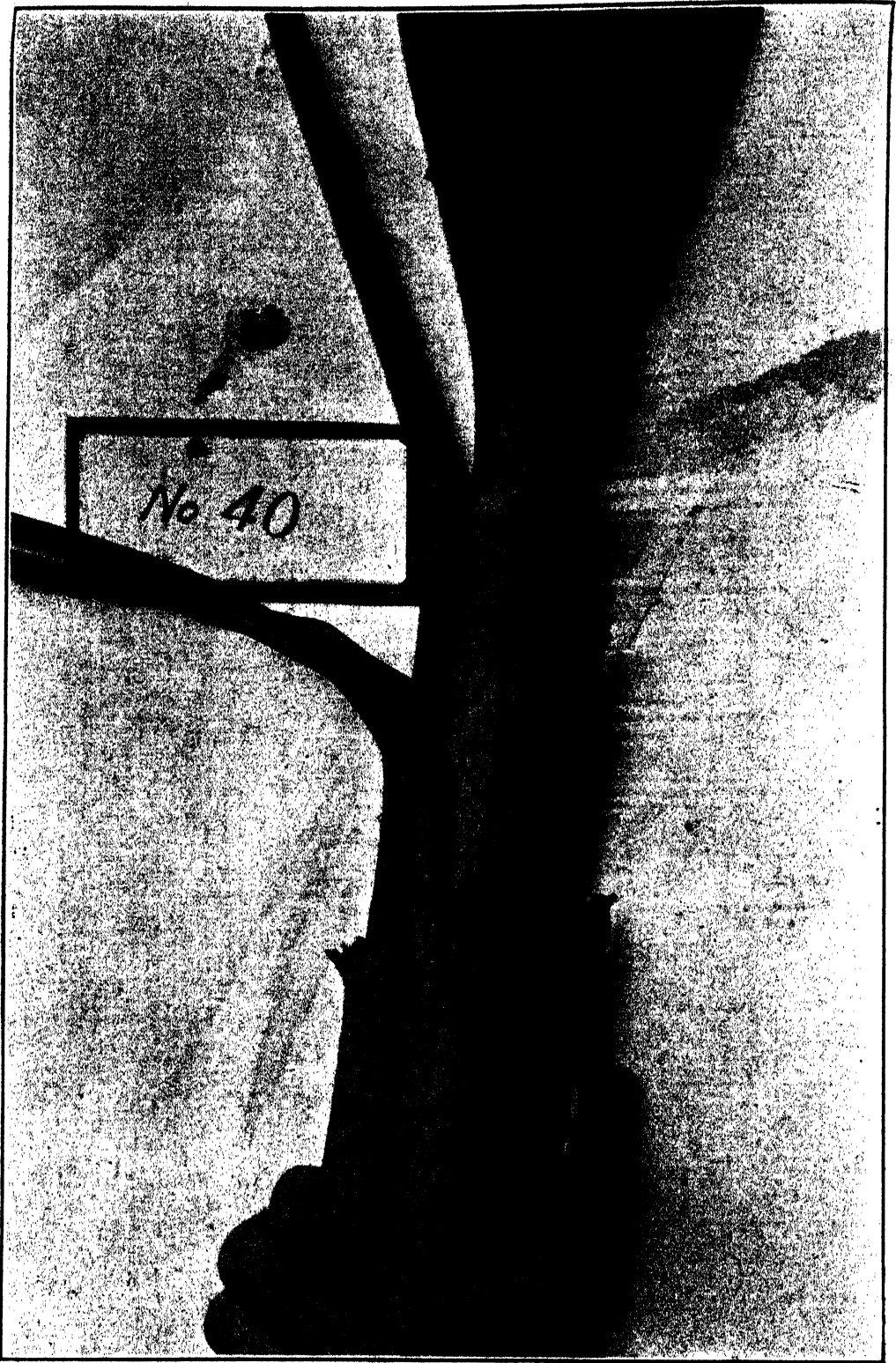


Plate 9. Stalk No. 40. Compare with similar pictures of Stalks Nos. 35 and 36.

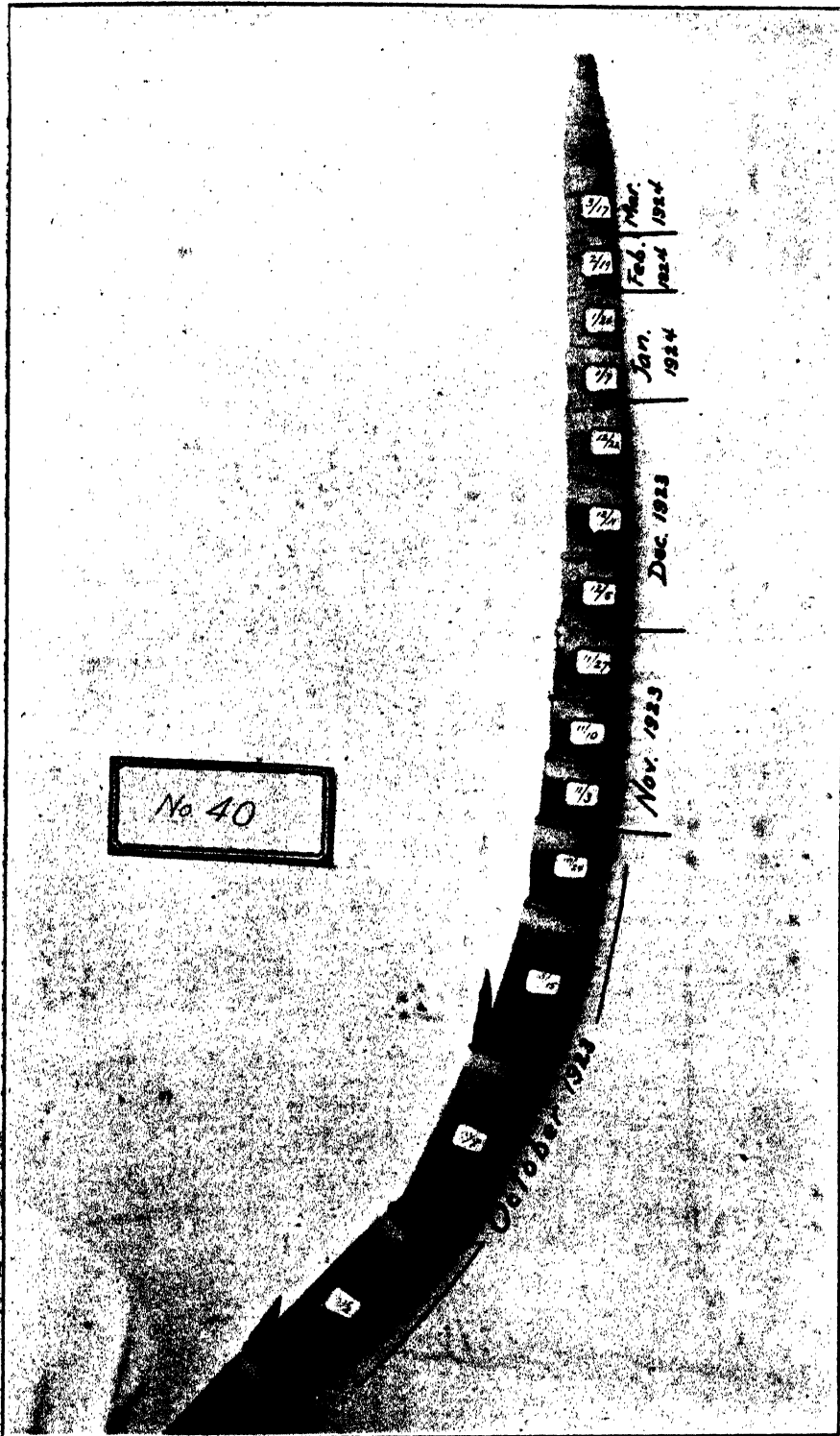


Plate 10. Stalk No. 40. Compare with similar pictures of Stalks Nos. 35 and 36.

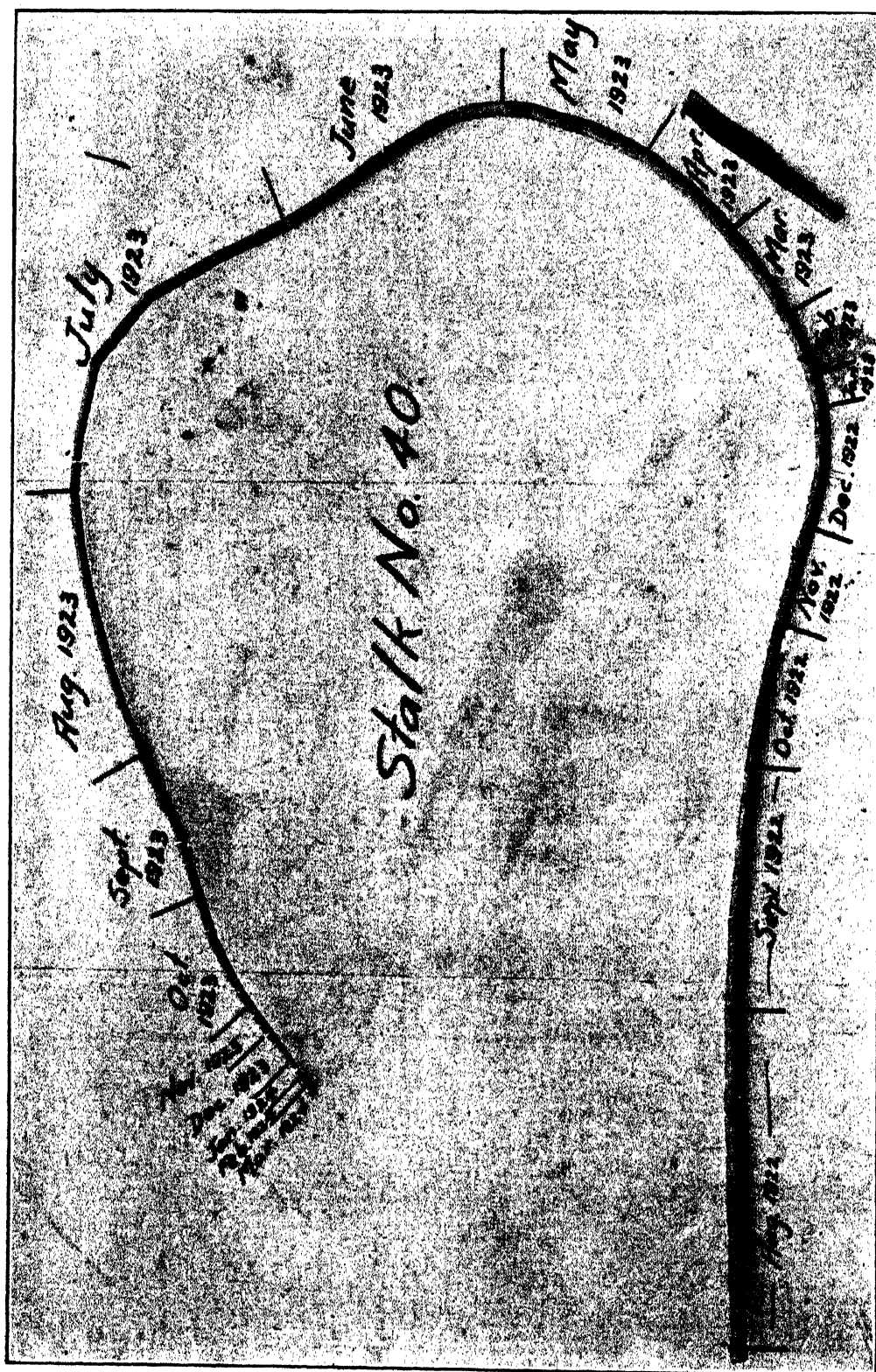


Plate 11. Stalk No. 40. Compare with similar pictures of Stalks Nos. 35 and 36.

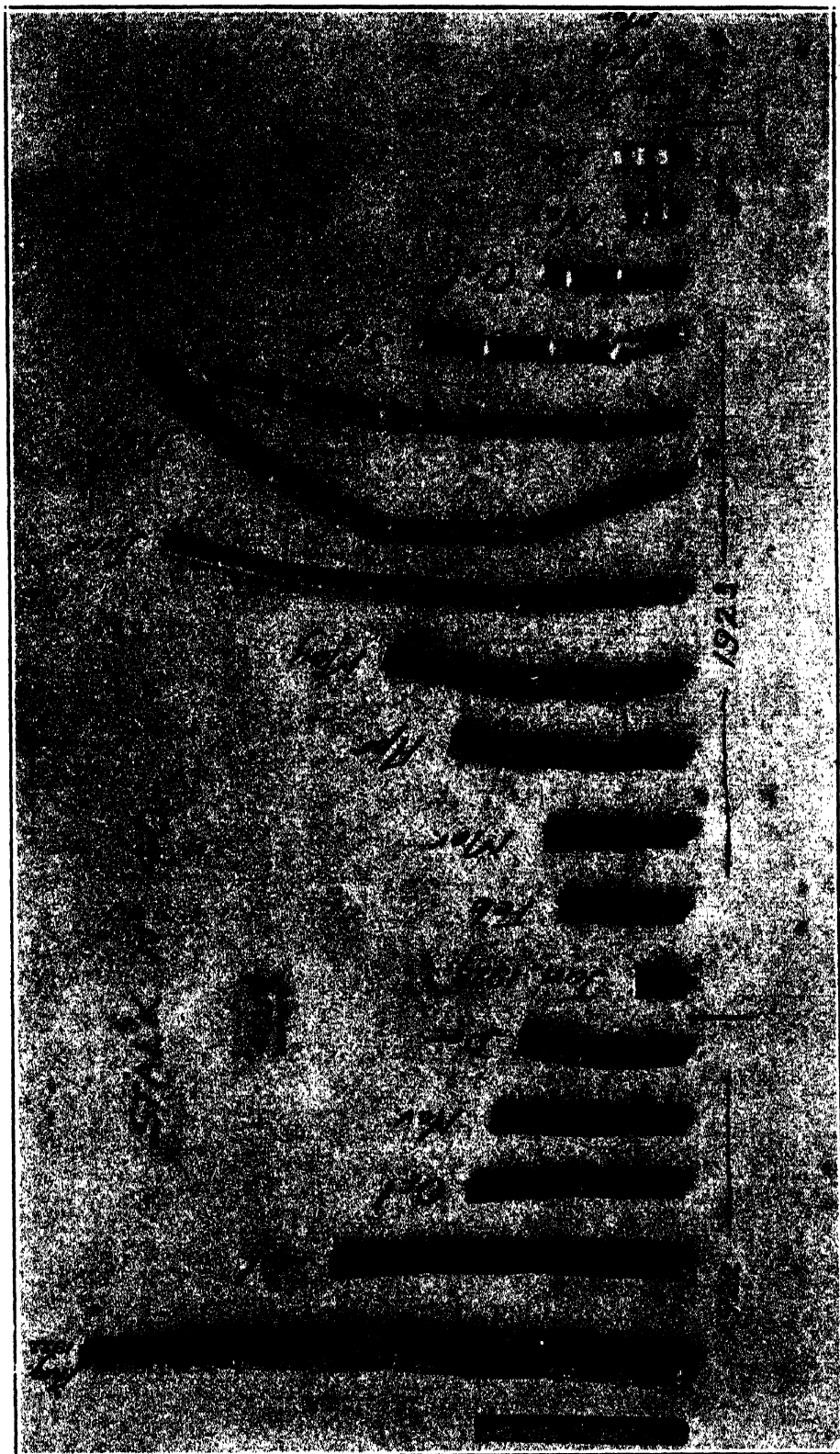


Plate 12. Stalk No. 40. Compare with similar pictures of Stalks Nos. 35 and 36.

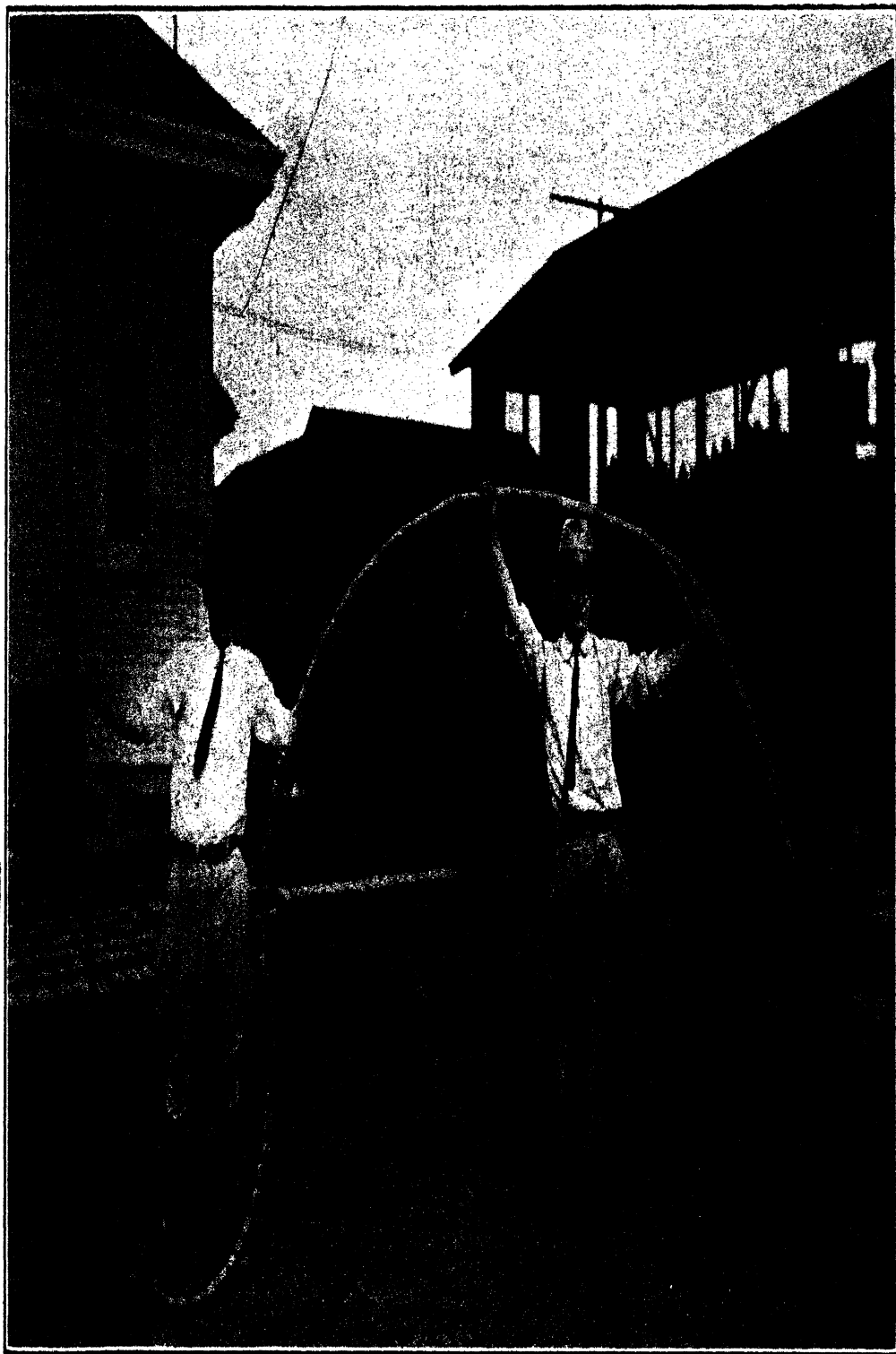


Plate 13. This shows typical stick of sugar cane as grown in the cross-breeding experiments discussed in this article.

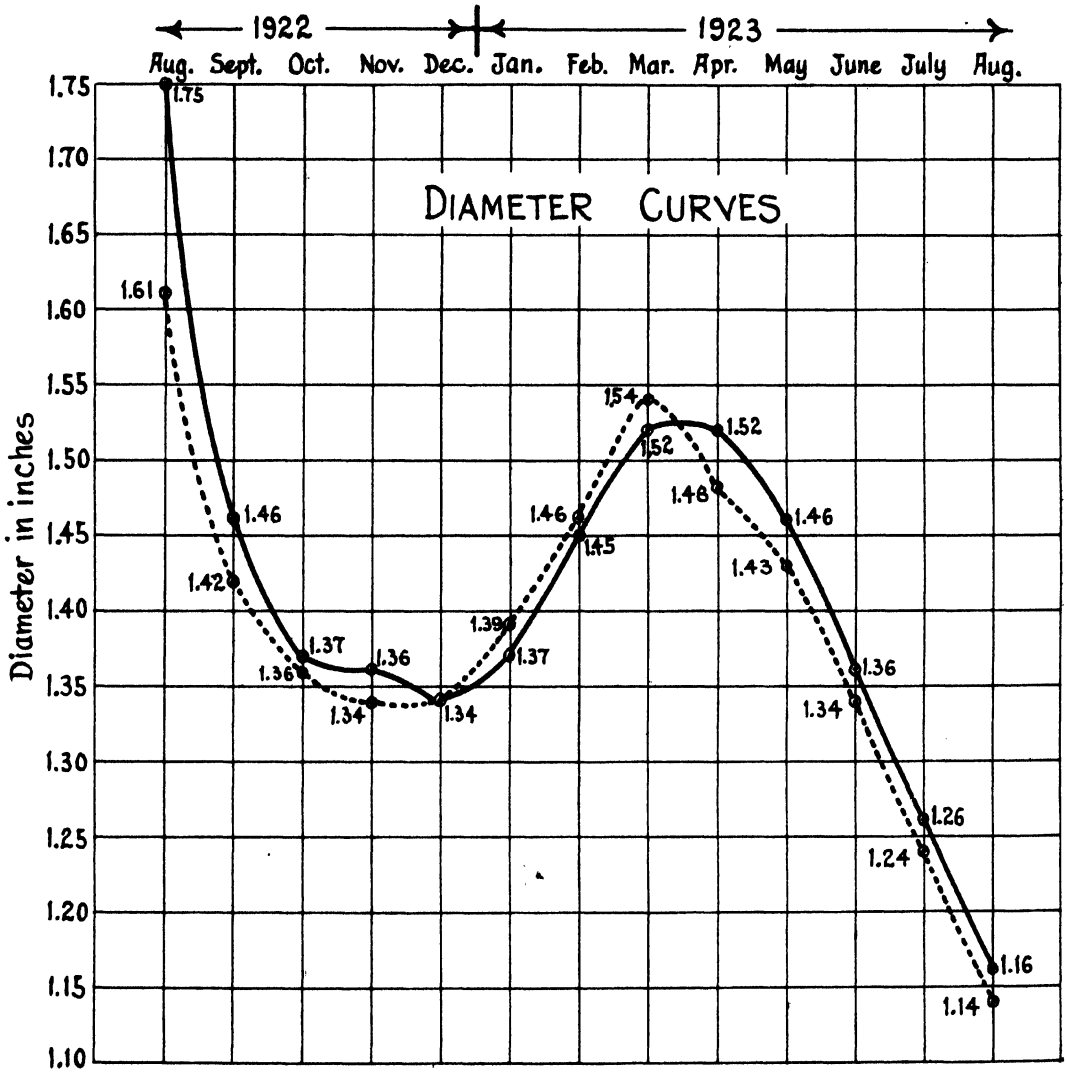


Fig. 7. Average diameter curves for six stalks of H 109 cane, showing differences at an interval of six months. The solid line (—) represents cane 18 months old. Measurements made on each month's growth from August, 1922, to August, 1923. The broken line (---) represents the same cane 24 months old. Measurements made on each month's growth for the same period of time (i. e., August, 1922, to August, 1923). In each case measurements were made at the same places on each stick, using a micrometer caliper.

Rodent Control in Hawaiian Cane Fields*

By C. E. PEMBERTON.

Among the numerous factors operating in destruction of food, the rat and the mouse play a conspicuous part the world over. These time-honored pests have been trapped, drowned, clubbed, burned and generally mistreated by humanity for ages, and have responded since the dawn of history to the present day by taking an annual toll in food products amounting to many millions of dollars in every civilized country and by spreading diseases fatal to man, at a rate all out of proportion to the abuse received at his hands. We have declared no truce with our ancient and innumerable foe. The war goes on. It were but an idle boast to say that victory is in sight or great progress made during the past twenty years in rodent warfare, when we learn that some ten million men, women and children died in India alone from rat plague since the last great pandemic started in Canton, China, in 1894. This average annual mortality of nearly 500,000 souls for India, not to mention a heavy fatality among most of the other races of mankind, and even here in Hawaii, where it still persists, is ample proof that enlightened man with all of his marvelous advance in every branch of science, at present still lives in close daily association with a pest which continues to increase and which, we believe, has a population even greater today than ever before.

This great prosperity in the rodent ranks would seem to depend solely upon the growth of human population and the coincident increase in the production and storage of food. Admittedly, rats and mice, in general, exhibit a total indifference to our obviously puny efforts towards their extermination or even control. Can we, the investigators, the biologists, the scientists, who are entrusted to captain the battle, feel optimistic with the present outlook? Can we confidently inform our fellow-men that rodents have been placed under any control whatsoever, by our efforts, when we know from the most authoritative estimates that the United States suffers an annual loss, from their depredations, amounting to from thirty-five to fifty million dollars, Great Britain an equal amount, Germany forty-seven and a half millions, France thirty-eight and a half millions, and little Denmark three millions? What can we answer to such an estimate as that made by David E. Lantz, of the U. S. Bureau of Biological Survey, when he found on careful consideration that the city of Baltimore loses foodstuffs yearly, through rodent activities, amounting to \$700,000.00 in value, and Washington, D. C., \$400,000.00? Have we prospered in our warfare? Rats and mice would seem to have found their Utopia.

* Presented at the Sugar Section of the first Pan-Pacific Food Conservation Conference, Honolulu, July 28 to August 14, 1924.

Rodent control is by no means the least important of our problems in the Pacific and in the countries adjacent thereto. The reality and seriousness of their depredations fully justify us in placing them among the important subjects included in this conference.

In the Pacific we have, in recent years, some striking examples of what rats and mice may do when food, housing and climate favor them. During the late World War losses in Australia at large grain-storage centers, became a great burden to the producers. The invasion of rats a few years ago on Lord Howe



Damage to cane by rats can be greatly reduced by systematic methods of poisoning, as described in this article.

Island, off the coast of New South Wales, promises to be a classic in the history of the advance of this rodent. The very existence of its few inhabitants has become threatened. Producers of copra in some of the Pacific Islands suffer heavy losses and where sugar cane is grown the problem often becomes particularly acute. In Java, India, Australia, the Philippines, the Mariana Group and in Hawaii we have heard much of the destruction to growing cane by rats.

Because of these losses in Hawaii on certain of the sugar plantations, a determined and well organized campaign in rodent control has recently been launched, which, because of the extent of the operations and the results which so far seem to have been obtained, make it of particular interest and perhaps worth special mention at this conference. With the ever increasing efficiency in the production of sugar in Hawaii and the gradual elimination of many of the problems that have appeared, planters in these islands have grown to feel, perhaps more so than in most other agricultural regions, that any problem in their business is highly susceptible of solution. A history of their achievements would tend to indicate this as a natural sequence. Hence the rat problem, which had been shelved as of secondary importance for many years, finally received attention and on one plantation on the island of Hawaii a bold and carefully laid plan of warfare was plunged into and a system of operation developed, which, we judge, even in one year's time, brought consternation in the array of the enemy. Because of these results and the interest thus aroused, it is the purpose of this paper to briefly summarize the extent of the problem, the procedure at Honokaa where the work has been done and outline how far success has been attained, so far as we can judge, and wherein there is yet failure.

The sugar industry is affected by rats, not so much in the final product as in the field. Rats are particularly fond of the sweet stick, securing therefrom the greater part of their carbohydrate requirement. Large holes are eaten into it or sometimes the stick is eaten clear through. Wherever even a single joint is so injured, souring, fermentation and rot follows up and down through the live tissue causing an appreciable deterioration in the purity of the juice in almost the entire stick and hence there follows a reduction in the quantity of sugar finally manufactured therefrom. Rats become so numerous on some of the plantations that the percentage of sticks so injured is large. At Honokaa plantation, where the extensive methods of rat control have been developed, estimates of the quantity of canes rat injured range from about 15 per cent to 25 per cent. Careful analyses of injured sticks have shown that those bearing an average injury lose from 10 per cent to 14 per cent of their sugar. From these data it is most surprising to know that at this one plantation alone the computation shows an annual loss conservatively estimated at from \$60,000.00 to \$75,000.00. To more fully appreciate the importance of the problem one need but examine the records of trapping operations at this one place. From 1914 to 1922 inclusive, several hundred steel traps, daily set in the cane and camps, caught the huge total of 347,762 rats. This shows the enormity of the rodent population, sustained in great part by live sugar cane. Such trapping, however, merely scratches the front line of the horde, for on the 14,000 acres of land covered, a few hundred traps can make a very small impression.

By 1922 it was realized that to combat such prolific and voracious animals required more heroic methods than the use of traps. Early that year poisoning was seriously considered. Without elaborating on the preparation and experiment preliminary to the adoption of a final system, it is sufficient to state that consideration was given to many forms of poison, which included poison gas, bacterial viruses, cyanide, arsenic, phosphorus, extract of squills, barium car-

bonate and strychnine. The latter two have given promise of being the best of the lot. Early experiments with both indicated that the best chances for control would probably be obtained through the adoption of a system of poisoning with these substances in exclusion of everything else. These two poisons were made up in baits and used extensively in 1922 and 1923 and are still being applied persistently this year. An examination of the cane in each field that was harvested in 1922, which had not received poison, showed rat damage in 18.9 per cent of the sticks. The poisoning in 1922 was in cane to be cut in 1923. When this 1923 crop was cut a similar careful percentage count was made in every field during the entire period of harvest. This showed an average rat damage of 4.29 per cent with a coincident disappearance of rats. Here was a great reduction in damage as compared with former years. We are faced also with the pleasant fact that though twelve deaths from bubonic plague occurred in the district in 1922, there was only one in 1923 and so far none in 1924.

Until proven otherwise we must assume that this cessation of heavy rat damage to the cane and the great reduction in the quantity of rats about the plantation, is due to the poisoning. The absence of human plague may be due to other causes, for it has not been confined solely to Honokaa, though of recent years Honokaa has been at the center of the human plague infection.

Of the two poisons used, barium carbonate has been the most widely distributed. It has been used in cake form, is cheap, highly toxic to rats, does not deteriorate, is almost tasteless and odorless and available in any desired quantity for such work as rodent destruction. The cakes are composed of wheat flour and middlings, with the white powdery barium carbonate mixed in at a proportion of three parts flour and middlings to one part barium carbonate. This is moistened, kneaded, rolled into one-fourth inch sheets and circular one-half inch cakes cut from it. These cakes are then dried and given a thin coating of paraffin for better preservation. They are distributed about three times a year in amounts of approximately one cake per 100 sq. ft. of land. No gulch, rock pile, camp or waste area is missed. As the area treated is about 14,000 acres, it can be well understood that the campaign is one of no small dimension. The selection and supervision of the labor in the application is an item in the work, of importance, since thoroughness of poison distribution has been proven highly essential. It has been found desirable also to test every barrel of poison before mixing it into baits. This is done with live rats kept for the purpose. Over 350 separate tests have been concluded. They further serve to confirm the original contention both here and in other countries that barium carbonate, as well as strychnine, is strongly toxic to rats. Wheat, coated with crystals of strychnine (alkaloid) at the rate of one ounce strychnine to 25 lbs. of grain, has also been extensively used, the wheat being applied in paper torpedo form, using about one-third ounce of wheat per torpedo package. This is a satisfactory poison, as is being demonstrated by some of the other plantations in Hawaii and in other parts of the world.

Except in large cane, the distribution of the two types of poison just described, can be broadcast from horseback at low expense. The manufacture and appli-

cation of these poison baits at Honokaa has cost about \$5,000.00 a year. Judged from the results to date the cost is negligible.

The problem has not been one of finding a poison that will kill rats. Many poisons have long been known to be fatal to them when they eat it. Barium carbonate and strychnine have been recommended and used in many parts of the world for years. The problem has been here, as elsewhere, one of inducing rats to eat substances which will kill them. This involves the mixing and masking of materials in form attractive and suitable to their taste and then placing it out in such quantity and frequency that the rate of mortality exceeds the birth rate. It sounds simple enough but were this true we would have no rat problem today. Of necessity, when dealing with such a host of rats, strict economy is required in the choice of materials used in the bait. Expensive and palatable substances such as cheese, bacon, fruits, etc., might be used by the wrathful housewife in laying a bait to gain revenge on a wily rat, but the farmer with thousands of acres to protect, has no recourse to such luxuries. Hence deeply involved in the problem are the two questions of palatability and economy. The hard, dried, wheat-cake above described containing the almost odorless and tasteless barium carbonate comes nearer to answering the requirements than any other bait yet developed at Honokaa. It is far from perfect. It is not particularly attractive, nor does flavoring seem to improve it. Still it is practical and enough rats seem to take it to accomplish, in part, the end striven for. The same can be said of strychnine-wheat though its cost is considerably greater than that of the barium carbonate cake.

Much has been said and written of the cunning nature, keen instinct and intelligence of the rat. Two years of constant study and field experience with the rat at Honokaa would at least fully confirm the assertions respecting a remarkable endowment of senses in hearing, tasting and smelling. All the difference between success and failure in rat control can result from the slight moulding of the baits before application. It has been just lately determined that a very great difference in the percentage of poison cakes eaten will occur if the barium carbonate is mixed all through the cake or only compacted as a central core. In the former, much fewer cakes are consumed than in the latter. This indicates how readily a rat may recognize the presence of poison at the first nibble though the material be to us absolutely odorless and tasteless. The slight alteration in the distribution of the poison in the cake by fixing it in the pure state, but sweetened, in the center, but not on the surface, has enabled us to score a point on the rat by inducing it to gnaw into the pure poison. This is because of the edibility of the unpoisoned coating. This new form of bait is proving more fatal in the field and laboratory than the old. Mixtures may thus prove less effective than baits resembling sandwiches or encrusted pills. It must first pass the tests of months of time and experience.

In connection with any comprehensive investigation of rats, a thorough test of a plan of extermination involving sex control should be included sooner or later. This theory, championed notably by William Rodier, of Australia, and apparently successfully applied by him against rabbits, is based on the belief that any tilting of the balance of sex ratio, in favor of the females, heavily

assists the rat in the fulfillment of its polygamous instincts and thereby increases the number of offspring in the life of each female. In other words, by destroying males more rapidly than females the birth rate proportionately increases, and vice versa, the reduction of females and protection of males tends toward extermination through the activities of the latter. We believe the theory to be sound, but impractical in application to rats owing to the insurmountable difficulties implicated in the capture and liberation of males and destruction of females in quantity sufficient to materially reduce a rodent population of millions, rather than thousands, whose increase from a single pair in one year may reach 800 in number where food is sufficient and climate salubrious. In correlation with this theory we are told that man's perpetual warfare on rats, by its very method, has favored their increase, since trapping, poisoning, etc., destroy more males than females, owing to the greater boldness and activity of the former. Certainly all sex determinations the world over on trapped rats have shown a preponderance of females, the conclusion from this being that our warfare has kept the males reduced. We feel, however, that in poison control the theory hardly applies. We cannot unreservedly conclude that males must necessarily eat much more than females or in feeding show less acuteness in the avoidance of poisons. We can hardly conclude that the so-called Rodier theory yet applies at Honokaa, for the poisoning has surely checked rather than increased the rodent population.

Any control of rats by poisoning must be continuous. There can be no let up. Their potentialities for increase are enormous and any reduction only enables those remaining the better to mature and reproduce. A day or week annually set aside for rat destruction, though it be conducted on a wholesale scale can be of little avail. Until we recognize the problem as one requiring continuous attention, on a broad scale, classed with all other important items in food production such as irrigation, fertilization or cultivation, progress will be but short-lived. An acceptance of the question in this light has been largely responsible for the partial success already attained at Honokaa. The neglect of a single large field of cane, or a slip in the machinery of the adopted system has several times been believed to account for an uprising of rats in that field.

Though the gray, or so-called migratory rat, *Rattus norvegicus*, is the one we have primarily to deal with and is said to be strongly nomadic in habit, we believe these sporadic outbreaks, which still appear in the poisoned region, to be sudden enlargements of more or less permanent colonies within the fields, which escaped thorough poisoning, rather than over-night invasions from the adjacent unpoisoned country.

As indicated above we would not leave the impression that this poison campaign has developed a degree of control in excess of our expectations or led to results that leave little for improvement. There have been several isolated outcroppings. Unexpected and heavy damage has appeared in spots. The chain is weak in places. The results, in general, cannot be said to be better in 1924 than last year and it leaves us yet in some doubt for the future. But we have only to recall the situation prior to the advent of poisoning to realize that there has been a large saving for two consecutive years and that the fields, though today showing damage in places, are in general much improved. It leads us to hope

for bigger results through an enlargement of the system and improvement of the bait.

What are the possibilities for better rodent control in our cities? To one who has struggled with the problem and seen some degree of success on a 14,000-acre sugar plantation, situated in a rough, steep, irregular country, interspersed with no end of deep gulches overgrown with a tangle of shrubbery, where rock piles and waste areas in further tangle are numerous and where an ideal home for this ground-inhabiting rat would seem to be reserved, the problem in cities would appear quite small. When, knowing the physical difficulties of distributing poison in well-grown sugar cane, where an almost impassable jungle is entered, where distance and direction are easily lost, and where the chances for poison bait deterioration through rain, irrigation, etc., are great, the problem in cities dwindles to still smaller proportions. In comparison, the situation for conducting a systematic control in all cities would seem ideal. Carefully laid plans could be exactly and timely executed. It is not, however, wholly simple. The variety of food utilized by rats in cane fields cannot be great. In cities, it is, and most baits applied would not be as readily acceptable to a city rat as in the field. However, it is believed that not enough system or perseverance is generally used in poisoning rats and that the conduct of some continuous plan, such as is being carried out at Honokaa, must be the only one whereby constant control can be achieved, both in the city and in the field.

Present Needs in Cane Disease Control*

By H. ATHERTON LEE

An ounce of prevention is worth a thousand pounds of cure. This is the old Scotch epigram modified to fit the situation in regard to the curing of cane diseases, and it is not at all difficult to find instances to illustrate the truth of this old saying.

Take the case of mosaic disease, nearly all cane men know of the outbreak of this trouble in Porto Rico. There is considerable circumstantial evidence to indicate that mosaic disease has been well established in oriental countries for years and that it is a trouble comparatively new to sugar countries of the Western Hemisphere. Mosaic disease was known in Java as early as 1890 and has existed in the Philippines for years; it was first noticed in Porto Rico in 1916. The disease is known to have spread to Egypt on cane cuttings imported from Java. Cuttings of cane from Java are also known to have been imported into the Argentine, and it is known that cuttings with mosaic disease were introduced into Porto Rico and Cuba from the Argentine.

* A paper presented at the First Pan-Pacific Food Conservation Conference, under the auspices of the Pan-Pacific Union.

If we go back over this trail, therefore, it can be seen where mosaic disease could have been stopped inexpensively and easily. If the cane introduced into the Argentine had been carefully selected in Java, there would have been no mosaic disease in the Argentine. If the cane had been carefully selected in the Argentine before its introduction into Porto Rico, the trouble would have been prevented very economically in Porto Rico. Exclusion of mosaic disease would have saved Porto Rico from enormous expense, an expense which is being repeated year after year and probably will be repeated annually for some time to come. Exclusion of mosaic disease would have saved sugar yields for the Argentine and for Cuba and for Louisiana, also, at practically no cost.

But there are other good illustrations of the way in which an ounce of prevention of cane diseases is worth many pounds of cure. Fiji disease, which is a comparatively new trouble in the Philippine Islands, is another good instance of how precautions to secure exclusion would have saved some of the growers



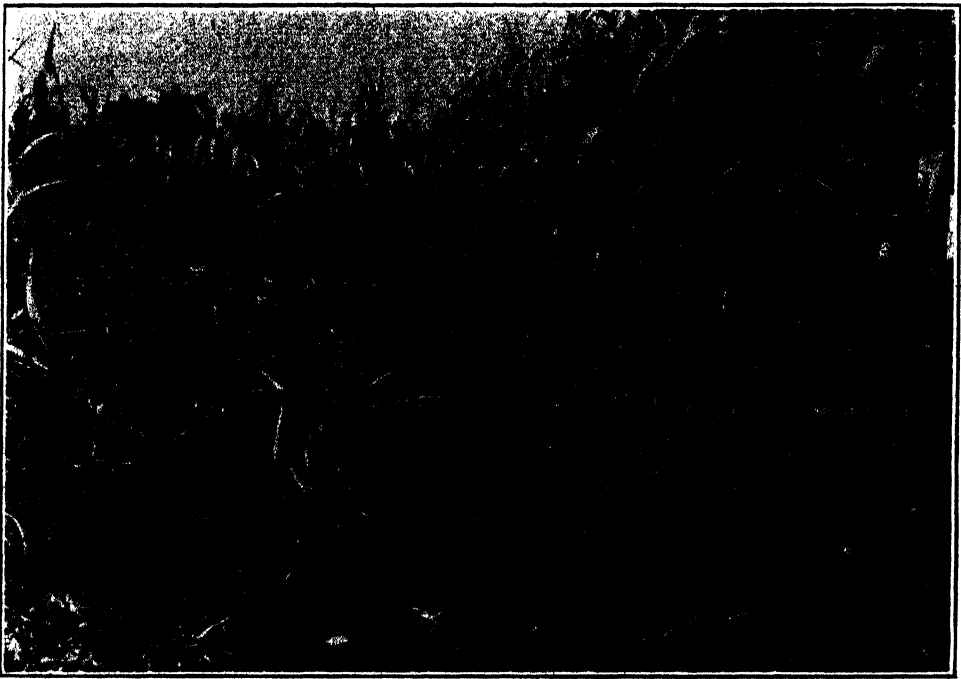
The effect of Fiji disease. At the left is a stool of the Luzon White variety showing the stunting effect of Fiji disease; at the right is a normal stool of the same variety.

considerable worry and added to their cane yields year after year. Fiji disease has been known in the Fiji Islands, Australia and New Guinea since the year 1910. In 1916, it was found in the Philippines and there is circumstantial evidence to indicate that it was introduced there on cane cuttings imported from Australia about the year 1912.

There are many other examples: Downy mildew of sugar cane is a disease carelessly imported into Formosa and later from Formosa into the Philippine Islands. A new trouble, known as red stripe, caused by bacteria, is an introduced disease in Hawaii; gum disease, also caused by bacteria, is an introduced

trouble in Porto Rico; wilt, caused by a fungus, is an introduced disease in the Philippines.

There are two extreme views in regard to cane diseases. One class of cane men regards all cane diseases as devastating, calamitous troubles, and the word "disease" to them brings up visions of blighted crops and bankruptcy. Another class looks upon all cane diseases as negligible troubles, similar in nature to leaf spots. There is a middle ground which regards cane diseases as having varying degrees of seriousness. Leaf spots, as a rule, are usually negligible except under extreme conditions favoring their development. On the other hand, there are more serious troubles, such as mosaic disease, Fiji disease, cane smut, downy mildew, and gum disease, which very materially lessen yields. Although entire destruction of a crop is a very rare thing, in some cases one or several of these diseases have been known to cause total failure in one or several fields. Whenever one of these troubles is at all common there is usually such a material reduction in yields as to form the difference between profit and loss, particularly in years of poor prices.



The rows of cane on the left are affected with Fiji disease; they are of the same age as the healthy cane on the right. This disease is not in the Western Hemisphere as yet. The cheapest cure in the Western Hemisphere is an ounce of prevention, that is, entire exclusion.

Probably the worst cane disease in the countries of the Western Hemisphere is mosaic disease. This is only one serious trouble, while in oriental countries there are a number of diseases, any one of them often as serious as mosaic and sometimes more serious.

Fiji disease, for instance, is an infectious trouble, known to be transmitted by cane cuttings but the cause of which is unknown; it is now found in Fiji,

Australia, New Guinea and the Philippines, and has not yet been introduced into cane countries of the Western Hemisphere, nor has it reached Java, India, Mauritius, Natal or Egypt as yet. This disease can be prevented with no cost at the present time in Hawaii, Cuba, Porto Rico, Louisiana, the Argentine, Mauritius, India, Egypt, and Java by entire exclusion. In other words, now is the time to exercise the ounce of prevention for Fiji disease. No canes should be imported into these countries from Australia, the Philippines, or Fiji except after personal inspection by a competent authority on cane, cane diseases and cane insects. Even after such selection the new cane varieties, when imported, should be kept in isolation for the plant crop and one ratoon crop. Distribution of cuttings of the new imported variety should not be made until the first ratoon crop has been harvested. We know of no cane varieties, as yet, with any high degree of resistance to this trouble. H 109, the Cheribon canes, Yellow Caledonia, Uba and all commonly grown varieties are susceptible.

Downy mildew is another trouble, caused by a fungus, and known to be transmitted by cane cuttings; it is found only in Formosa, the Philippines and Australia and has not reached the Western Hemisphere and is still unknown in Java, India, Mauritius, Natal and Egypt. In the Philippines, Uba cane is especially susceptible to downy mildew.

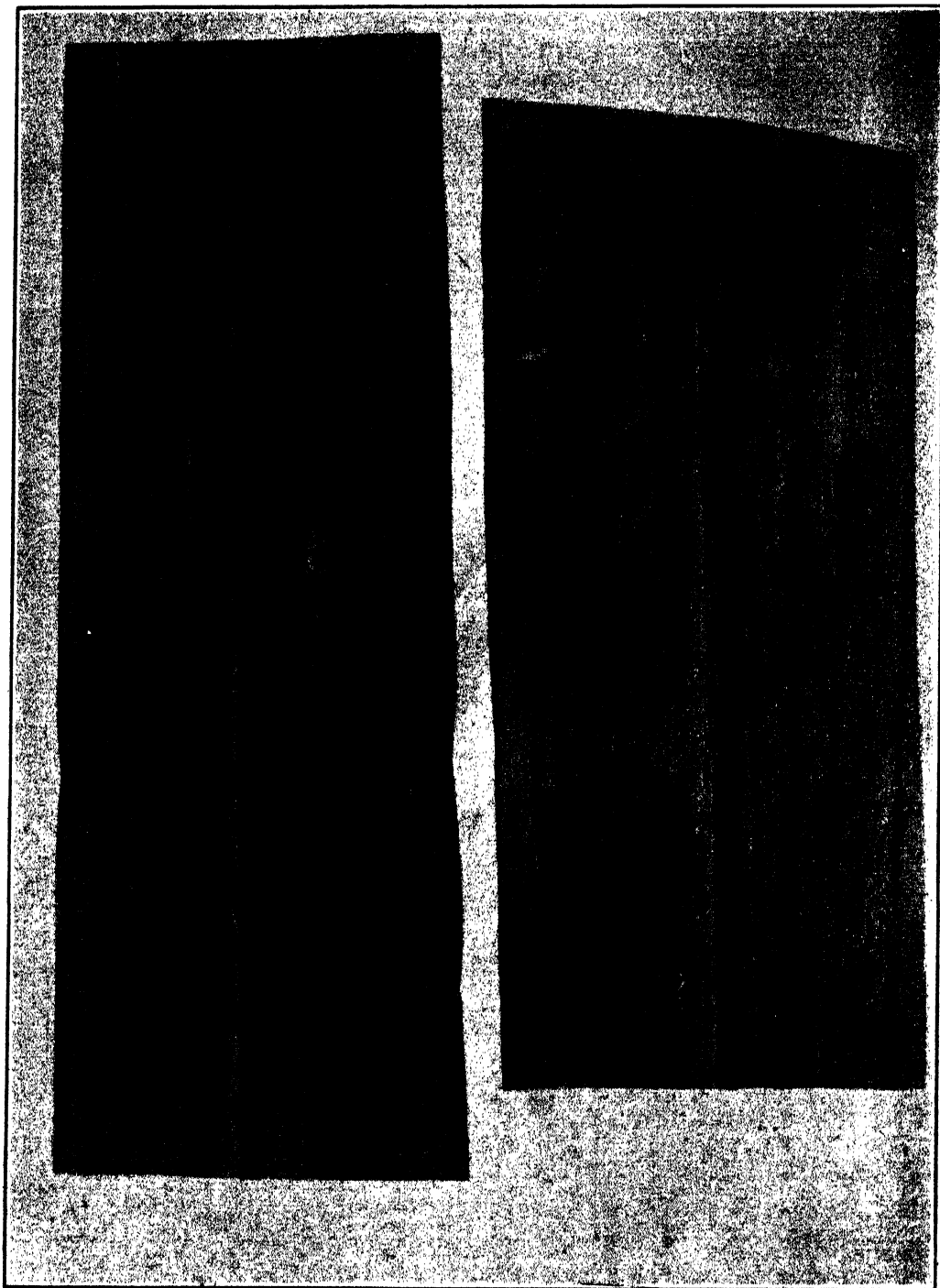
Cane smut, caused by a fungus, is known to be transmitted by cane cuttings. It is reported from India, Natal, Java, Italy, Mauritius, the Philippines and Australia, and two points in the Western Hemisphere, Trinidad and British Guiana. In the Philippines, Uba cane is also especially susceptible to cane smut.

Sereh is a trouble, the cause of which is unknown, but it is well established that it is transmitted by cuttings. It is authentically known only in Java as yet, although there are reports that it is also in Formosa. It is not known as yet in any of the other cane countries. It is probably only good fortune that it has not been introduced into the Argentine, since cuttings were imported there direct from Java.

Gum disease, caused by a bacterial organism, was first known authentically from Brazil and later in the year 1893, from Australia. It is also known in New Guinea, Mauritius, Reunion, and Porto Rico. What is considered a similar trouble is known in Java, Borneo and the Philippines. It is transmitted by cane cuttings. Gum disease is not known as yet in Hawaii, Formosa, India, Egypt, Natal, Louisiana nor Cuba. A new trouble is being reported from Australia, known as leaf scald, caused by a bacterial organism. It is not known from other countries. Red-stripe disease is a new bacterial disease in Hawaii which is not known in other countries.

These are the more serious troubles, the most of which have not yet become established in the cane countries of the Western Hemisphere. The absence of these diseases is a considerable advantage to western countries in competition with oriental countries where labor is so much cheaper. This advantage may be maintained by the exclusion of these cane diseases. What is needed in cane countries of the Western Hemisphere is a considerable campaign of publicity concerning these well established and destructive cane diseases in the Orient. Every cane man should know of the existence of these diseases in other coun-

tries, and having such knowledge, should insist that no cane importations be made except by competent cane men working in close contact with men versed in cane diseases and cane insects. It is a sad fact to contemplate, but in the illustrations of the importations of cane diseases which have just been related, in



Small longitudinal galls appear on both surfaces of the leaves of cane affected with Fiji disease. Such galls constitute a reliable feature for identification of the disease.

four instances, government experiment stations and rather well-known cane men are implicated as having brought about the introduction and distribution of these diseases; inadvertently and innocently, it is true, but nevertheless the harm has been done.

To summarize: an ounce of prevention against cane diseases is worth many pounds of cure. Now is the time for cane sugar producers in the countries of the Western Hemisphere to exercise the ounce of prevention against Fiji disease, downy mildew, sereh, cane smut, wilt, gum disease, leaf scald and possibly other unknown troubles and numerous insect pests.

If new cane importations are to be made, and progress in cane production necessitates such importations, selection of the cane cuttings to be imported should be made by a competent authority. The imported cuttings should be grown in isolation under government supervision for at least one plant crop and one ratoon crop. During this period of quarantine, inspection should be made several times each month by cane men working in close co-operation with cane entomologists and cane pathologists.

The Athel in California

By A. D. SHAMEL

In the spring of 1922, Mr. Bloomfield Brown, of the Hawaiian Pineapple Company, at Wahiawa, asked the question as to whether or not we knew of any rapid-growing tree other than the eucalyptus suitable for windbreaks. I suggested that the athel, or tamarisk, might be worth trying. It has been recently introduced in the Southwest and its rapid growth under desert conditions has been very striking. At Mr. Brown's request, I brought to Hawaii some cuttings of Athel, part of which were given to Mr. Brown and the remainder to the Experiment Station of the H. S. P. A.

Since this introduction, I have had the opportunity of studying rather extensive athel windbreaks in the Coachella and Imperial Valleys of California, on the Yuma Mesa and in the Salt River Valley of Arizona. These observations showed that the athel trees have made satisfactory growth in nearly every instance and that the hedges of these trees are satisfactory windbreaks. However, contrary to previous impressions, it has been found that these trees, under the conditions studied, are as competitive, if not more competitive, with neighboring plants than are the Eucalypti (*E. rudis*, *E. globulus*, *E. viminalis*) under the same conditions.

For example, near Brawley in the Imperial Valley, a grapefruit grower, Mr. Steiner, showed us roots of athel trees of a five- or six-year-old windbreak alongside his grapefruit orchard, extending 45 feet into the grapefruit orchard soil. On the Yuma Mesa, a windbreak of athel trees on the Hill Citrus Orchard property showed similar results of severe competitive conditions of growth

on the part of the athel trees. It may be that, under some conditions, the root growth of the athel trees will not be so competitive with neighboring plants as observed last summer in our study of this subject. However, it seems advisable, from our point of view, to proceed cautiously in Hawaii until the habit of growth of this tree is actually determined from experience.

I feel that it is desirable to try this desert tree in the dry districts of Hawaii both for windbreak and ornamental purposes, but only on a small scale until its habits of growth are determined in each district and under different soil and climatic conditions.

The Athel in Hawaii

By H. L. LYON

The athel, or evergreen tamarisk, *Tamarix aphylla*, gives promise of becoming a valuable tree in Hawaii, but its range of usefulness and its adaptability to our varying conditions of soil and climate, have yet to be determined.

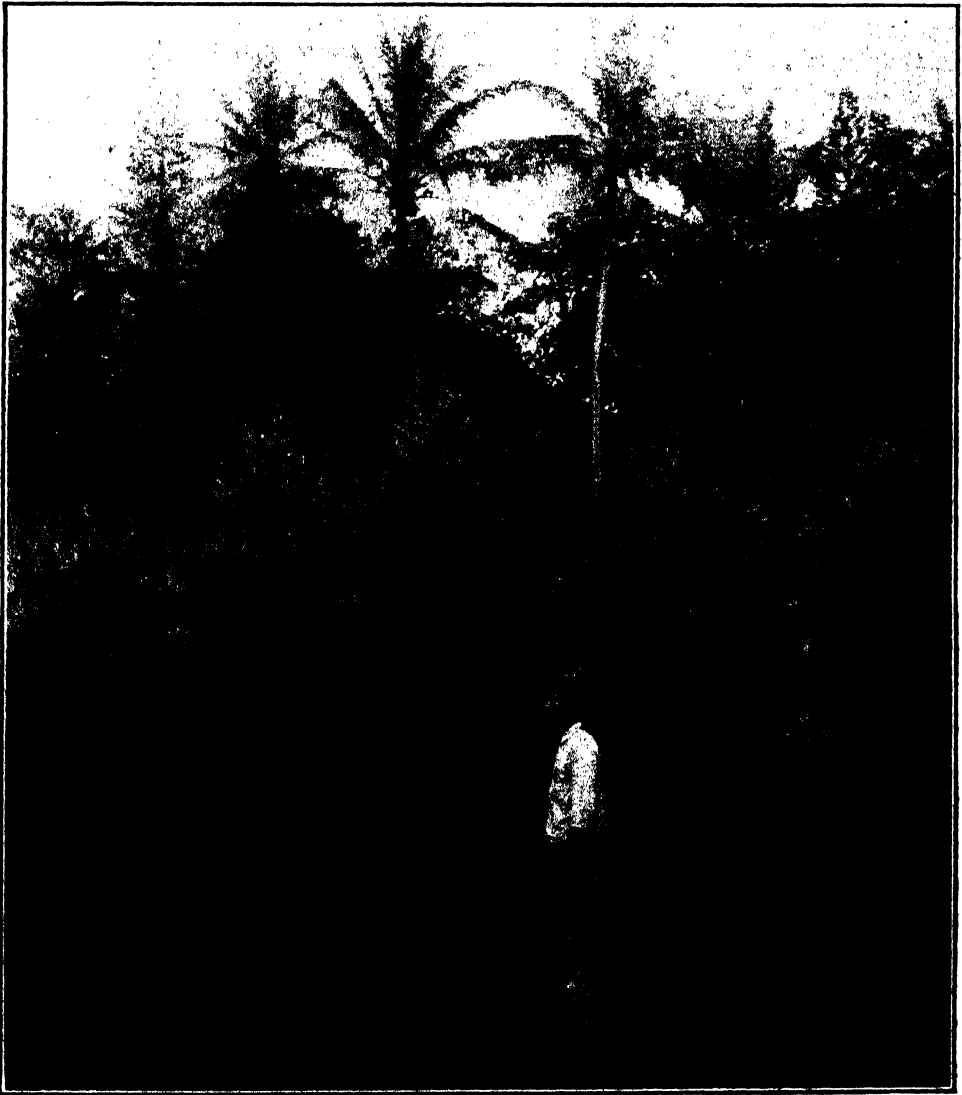
This tree was introduced into the United States from the arid regions of Northern Africa and has been strongly recommended for planting in the deserts of Arizona and southern California. It has been frequently stated that it did not produce surface roots and consequently would not interfere with the growth of neighboring plants. According to A. D. Shamel, who brought the first Athel cuttings to Hawaii, this has been proven an erroneous conclusion. In the short note which precedes this article, Mr. Shamel tells us that under certain conditions in California, the Athel is proving "as competitive, if not more competitive, with neighboring plants than are the Eucalypti." This is a matter which should be taken into consideration whenever extensive plantings of this tree are contemplated.

The numerous tamarisk cuttings which we have distributed in recent months were all imported from California, but we are now able to supply a limited number from our own trees growing at the nursery in Honolulu.

Our first experience with this tamarisk was not encouraging, but since we have discovered the treatment which it requires, we are obtaining much better results. Cuttings planted at the Vineyard Street Nursery during May, 1923, had produced trees which measured 11 feet tall on the first of April, 1924, and 16 feet tall on the first of August, 1924. Cuttings planted in an exposed situation above Wahiawa, at about 1,000 feet elevation, have produced thrifty shoots which are, however, rather slow-growing. We find that the cuttings should be placed in the ground where the trees are desired, for very few of our bedded cuttings have survived transplanting. They should always be planted where they will get full sunlight, for the trees seem to object to even partial shade. They may be started in pots or cans and then transplanted to the ground, but this must be done without disturbing the soil about their roots and we would not recommend this procedure where open ground planting is possible.

The method of handling which we would now recommend is somewhat as follows: Dig holes 12 inches by 12 inches by 18 inches deep, 3 to 5 feet apart. Plant one cutting, slightly inclined, in each hole, the top of the cutting to be about level with the original surface of the soil, and the hole to be filled within 3 inches of the top. This will, of course, leave about 3 inches of the cutting exposed. Keep the soil moderately moist by irrigating when necessary, but do not keep it in a soggy condition. When the young shoots attain a height of 12 to 18 inches, fill in the holes to cover the lower ends of the shoots so that they may develop roots independent of the old cuttings. Large shoots not anchored by their own roots are apt to be split off from the cuttings by the wind.

In general appearance, the athel suggests a *Casuarina* or ironwood. It is a very graceful tree with grey-green foliage and ranks high as an ornamental, being especially attractive when in flower. As it thrives best in hot, sunny situations, we should not expect it to flourish in very wet regions or at high elevations.



These trees were eleven feet tall when eleven months old.

Some idea of the character of this tree may be obtained from the following quotations from literature:

This interesting and beautiful native of the Sahara, contributed to American horticulture by Dr. Trabut, is proving to be an ideal plant for windbreaks in the deserts of southeastern California. The absence of surface roots is a valuable feature, as it makes it possible to grow other plants close to the rows of *Athel*.

Eighteen months after the cuttings were planted, the trees had reached a height of 20 feet and when 5 years old, some of them were 50 feet high and from 14 to 19 inches in diameter at the base of the trunk.

Rapid growth is by no means the only merit of this tamarisk, for it is highly ornamental and the wood not only supplies excellent fuel, but is said to be of value for construction purposes.

(Kearney, T. H. *The Journal of Heredity*, 13:157 and 160, 1922.)

A small to moderate-sized tree with feathery foliage; an erect, tapering trunk, and rough grey bark, attaining a height of 60 feet and a girth of 6 to 7 feet or more.

An important tree in arid regions, the wood being used for agricultural implements, turning, and other purposes, as well as for fuel.

It thrives in arid regions with extremes of temperature, where the thermometer reaches a shade temperature of 120 degrees F. or more in the hot weather, while in the winter it sinks below freezing-point; the rainfall in parts is as low as 3 inches.

It coppices freely, sending out quantities of shoots, and grows readily from cuttings but does not produce root-suckers.

The growth is much faster on low-lying ground subject to inundation than elsewhere. (Troup, R. S. *The Silviculture of Indian Trees*, 1-18-20, 1921.)

Does Liming Pay?

By J. A. VERRET

For a number of years we have been conducting field experiments to determine the value of liming on the fields of the various sugar plantations. In this article we propose to give a summary of our results to date.

Some confusion exists in the popular mind with reference to the nature of lime and its use. Before proceeding with our summary, it may be well to discuss these points briefly.

When the chemist speaks of "lime" he refers to calcium oxide (quicklime) only, but when we refer to lime in the agricultural sense we include three different materials: burned or quicklime (calcium oxide), hydrated or water-slaked lime (calcium hydrate), and ground limestone or air-slaked lime (calcium carbonate). Gypsum or calcium sulphate is not included in the term "lime" although it contains calcium.

These materials contain various amounts of calcium and for purposes of comparison are referred to quicklime, calcium oxide. That is: 56 pounds of quicklime equals 74 pounds of hydrated or water-slaked lime or 100 pounds of ground limestone. The other way about, 100 pounds of quicklime equals 132

pounds of water-slaked lime or 179 pounds of ground limestone. With these figures in mind, one may figure the relative costs. When either quicklime or hydrated lime is exposed to the air, they gradually absorb carbon dioxide and tend to change to lime carbonate, or limestone.

The function of lime in soils is given briefly as follows:

1. Lime materials serve as a source of the element calcium to plants. Calcium is one of the essential elements in plant growth. As a rule most of our soils are pretty well supplied with calcium; besides this, we apply fairly large amounts of it in the phosphates which we use in our mixed fertilizer and directly.
2. Lime materials have the power of shrinking clay and making it more pervious to water and air. Lime, therefore, makes clays and adobe soils looser, and improves the mechanical condition of this type of soils.
3. Lime materials (when used in proper amounts) make "sour" soils "sweet," changing an acid condition into a neutral or slightly alkaline one. This is essential to many crops, but our tests indicate that sugar cane is very tolerant to sour conditions although our best yields are obtained from neutral or slightly alkaline soils.
4. Lime materials are necessary for the beneficial bacteria and other micro-organisms of the soil.
5. Lime materials promote the normal decay of organic matter in the soil.
6. Lime materials, under some conditions, make soluble some of the insoluble forms of the more valuable plant foods such as potash and the phosphates.
7. Lime materials, when added to nearly or complete neutrality, precipitate soluble alumina.

For the purpose of loosening heavy soils mentioned in (2) burned or hydrated lime is to be preferred when prices allow. It acts more quickly. Lime is best applied before plowing, several months before planting, particularly if quick or hydrated lime is used. On the sour, lighter, sandy or loam soils, ground limestone is to be preferred to either of the other two.

KAIWIKI SUGAR COMPANY, EXPERIMENT 1, 1917 CROP, LONG RATOONS
Lime applied before ratooning

Treatment	No. of Plats	Tons per Acre		
		Cane	Q. R.	Sugar
No lime	3	40.9	7.21	5.67
2 Tons coral sand.....	2	44.1	7.50	5.88
4 Tons coral sand.....	2	42.1	7.46	5.64
1 Ton quick lime.....	4	40.0	7.39	5.43
Average all lime plots.....		42.1		5.65

WAIPIO SUBSTATION, EXPERIMENT "O," 1918 CROP, FIRST RATOONS, LONG

Lime applied in furrows and mixed with soil

Treatment	Tons per Acre		
	Cane	Q. R.	Sugar
2 Tons coral sand	86.7	8.63	11.51
No sand	87.7	7.37	11.97
1 Ton lime per acre.....	82.9	6.94	11.97
No lime	84.7	7.37	11.32
6 Tons coral sand	82.8	7.27	11.40
No sand	80.1	7.37	10.96
12 Tons coral sand	69.1	7.15	9.71
No sand	67.7	7.37	9.15
Average all lime plots.....	80.4		11.15
Average all no lime plots.....	80.1		10.85

WAIPIO SUBSTATION, EXPERIMENT "O," 1918 CROP, FIRST RATOONS, LONG

Coral, Sand, and Lime, Residual Effect

Treatment	Tons per Acre		
	Cane		Sugar
2 Tons coral sand	95.7		10.44
No sand	93.9		10.72
1 Ton lime	93.0		9.91
No lime	90.9		9.93
6 Tons sand	83.9		9.28
No sand	83.6		9.01
12 Tons sand	79.5		9.84
No sand	68.1		8.48
Average all lime plots	88.0		9.87
Average all no lime plots	84.1		9.29

WAIPIO SUBSTATION, EXPERIMENT "O," 1920 CROP, THIRD RATOONS

Testing residual effect of lime

Treatment	Yield per Acre		
	Cane	Q. R.	Sugar
Lime	66.1	8.03	8.37
No lime	64.2	7.82	8.34

WAIPIO SUBSTATION, EXPERIMENT "O," CROPS 1916, 1918, AND 1920

1918 and 1920 crops residual effect

	Cane	Sugar
Average of 3 crops—sand	78.3	9.79
Average of 3 crops—no sand	76.1	9.49

WAILUKU SUGAR COMPANY, EXPERIMENT 1, 1917 CROP

Sand applied after furrowing and before preparing, plant cane

Treatment	No. of Plots	Yield per Acre	
		Cane	Sugar
10 Tons coral sand	36	86.4	12.40
No sand	36	81.2	12.18

WAILUKU SUGAR COMPANY, EXPERIMENT 1, 1919 CROP, FIRST RATOON

Residual effect of coral sand

Treatment	No. of Plots	Yield per Acre	
		Cane	Sugar
Sand	36	74.1	10.87
No sand	36	71.2	10.68

KILAUEA SUGAR PLANTATION COMPANY, EXPERIMENT 4, 1917 CROP

Treatment	No. of Plots	Yield per Acre	
		Cane	Sugar
Sand	32	27.2	3.09
No sand	32	25.5	2.94

KILAUEA SUGAR PLANTATION COMPANY, EXPERIMENT 7, 1918 CROP

To test value of coral sand and reverted phosphate

Treatment	Yield per Acre		
	Cane	Q. R.	Sugar
Nothing	31.5	8.54	3.69
Sand	31.9	8.55	3.73
Reverted Phosphate	31.9	8.58	3.71

HAMAKUA MILL COMPANY, EXPERIMENT 1, 1918 AND 1920 CROPS

Comparing no lime with coral sand and ground limestone

Treatment	Yield per Acre			
	1918 Crop		1920 Crop	
	Cane	Sugar	Cane	Sugar
2 Tons sand	14.7	1.88	26.4	3.44
No sand	15.4	1.99	25.4	3.37
4 Tons sand	15.2	1.90	27.1	3.60
No sand	14.5	1.87	26.6	3.53
2 Tons ground rock	16.3	2.03	27.5	3.71
No rock	15.6	2.01	28.4	3.77
4 Tons ground rock	15.0	1.90	25.7	3.39
No rock	15.1	1.96	24.4	3.28
Average all lime plots..	15.3	1.93	26.7	3.53
Average all no lime plots	15.2	1.96	26.5	3.52

HAMAKUA MILL COMPANY, EXPERIMENT 2, 1918 AND 1920 CROPS

Comparing no lime with lime and ground limestone in long ratoons

Treatment	No. of Plots	Yield per Acre			
		1918 Crop		1920 Crop	
		Cane	Sugar	Cane	Sugar
1 Ton lime	4	11.2	1.32	20.5	2.75
2 Tons gr. limestone*	4	11.7	1.44	20.1	2.39
3½ Tons lime	4	10.7	1.25	20.9	2.68
7 Tons gr. limestone	4	11.2	1.35	21.9	2.69
No lime	9	11.0	1.34	19.2	2.43
Avge. all lime plots		11.2	1.34	20.8	2.63

*The higher results in these plots are due entirely to the yield from one plot (3B), which yielded 14.07 tons of cane and 1.72 sugar. No other B plot produced over about 11 tons of cane. The high yield in that plot is evidently not due to liming, but to soil variation.

OAHU SUGAR COMPANY, EXPERIMENT 8, 1918 CROP
Lime and gypsum on virginal land, applied in furrow before planting

Treatment	No. of		Yield per Acre		
	Plots	Cane	Q. R.	Sugar	
2,000 lbs. lime	12	67.8	9.56	7.25	
No lime	12	65.6	9.24	7.18	
4,000 lbs. gypsum	10	69.7	9.68	7.35	
No gypsum	8	73.6	9.89	7.40	

OAHU SUGAR COMPANY, EXPERIMENT 17, 1918 CROP

Coral sand applied to furrows and hoed in

Treatment	No. of		Yield per Acre		
	Plots	Cane	Q. R.	Sugar	
6 Tons coral sand	9	67.3	11.18	6.03	
No sand	9	67.6	11.06	6.11	

OAHU SUGAR COMPANY, EXPERIMENT 17, 1920 CROP

Residual effect of coral sand

Treatment	No. of		Yield per Acre		
	Plots	Cane	Q. R.	Sugar	
6 Tons coral sand	9	96.6	7.05	13.70	
No sand	9	101.6	7.43	13.68	

GROVE FARM COMPANY, EXPERIMENT 8, 1920 CROP

Sand applied before furrowing

Treatment	No. of		Yield per Acre		
	Plots	Cane	Q. R.	Sugar	
No sand	9	41.9	8.41	4.98	
3¼ Tons sand	9	40.7	8.29	4.91	
6½ Tons sand	10	39.5	8.45	4.68	
9¾ Tons sand	10	42.0	8.52	4.93	
Average all sand plots ...		40.7		4.83	

GROVE FARM COMPANY, EXPERIMENT 8, 1922 CROP

Residual effect

Treatment	No. of		Yield per Acre		
	Plots	Cane	Q. R.	Sugar	
No sand	9	35.50	8.49	4.18	
3¼ Tons sand	9	37.5	8.19	4.55	
6½ Tons sand	10	33.8	8.61	3.93	
9¾ Tons sand	10	33.3	9.49	4.01	
Average all sand plots ...		34.8		4.16	

HILO SUGAR COMPANY, EXPERIMENT 18, 1921 CROP

Lime applied to 4 ratcons and cultivated in by mules

Treatment	No. of		Yield per Acre		
	Plots	Cane	Q. R.	Sugar	
No lime	6	49.3		6.16	
2,000 lbs. quicklime	6	49.3		6.16	
8,000 lbs. coral lime	6	51.0		6.37	
Nothing	5	41.2		5.15	
12,000 lbs. quicklime	4	44.6		5.57	
Average all no lime plots			45.2	5.65	
Average all lime plots			47.3	5.91	

HILO SUGAR COMPANY, EXPERIMENT 18, 1923 CROP

Testing residual effect

Treatment	Yield per Acre		
	Cane	Sugar	
Lime applied to 1921 crop			
1 Ton quicklime	64.1	7.12	(N. B. Sugar estimated at 9 quality ratio)
4 Tons coral sand	62.4	6.93	
No lime	60.3	6.90	
6 Tons quicklime	54.6	6.07	
No quicklime	53.2	5.91	
Average all lime plots ...	58.9	6.65	
Average all no lime plots	56.8	6.31	

KAIWIKI SUGAR COMPANY, EXPERIMENT 4, 1922 CROP

Value of lime in acid soil

Treatment	No. of Plots	Yield per Acre	
		Cane	Sugar
No lime	8	24.6	3.39
6 Tons quicklime	8	24.5	3.21

KAIWIKI SUGAR COMPANY, EXPERIMENT 4, 1924 CROP

Residual effect

Treatment	No. of Plots	Yield per Acre	
		Cane	Sugar*
No lime	8	34.6	4.33
6 Tons quicklime	8	36.2	4.60

*Sugar estimated at 8 quality ratio

PEPEEKEO SUGAR COMPANY, EXPERIMENT 5, 1922 CROP

Value of lime in acid soil

Treatment	No. of Plots	Yield per Acre		
		Cane	Q. R.	Sugar
No lime	8	51.7	7.94	6.52
2 Tons Waianae lime	7	49.4	7.74	6.39
4 Tons Waianae lime	7	50.1	7.70	6.51
Average all lime plots		49.7		6.45

HAWI MILL AND PLANTATION COMPANY, EXPERIMENT 2, 1919 CROP

Value of lime in acid soil

Treatment	No. of Plots	Yield per Acre		
		Cane	Q. R.	Sugar
No lime	16	52.3	7.93	6.59
1,000 lbs. caustic lime	8	53.2	7.80	6.82
3,000 lbs. caustic lime	8	54.9	7.95	6.90
Average all lime plots		54.0		6.86

PAAUHAU SUGAR PLANTATION COMPANY, EXPERIMENT 11, 1919 CROP

Treatment	No. of Plots	Yield per Acre		
		Cane	Q. R.	Sugar
1 Ton lime	9	43.0	8.08	5.32
5½ Tons lime	9	44.5	8.18	5.45

PAAUHAU SUGAR PLANTATION COMPANY, EXPERIMENT 10, 1919 CROP

Treatment	Value of lime, plant cane		Yield per Acre	
	No. of Plots	Cane	Q. R.	Sugar
No lime	16	45.6	8.20	5.57
1 Ton hydrated lime	8	46.9	8.25	5.69
2 Tons hydrated lime	8	46.4	8.35	5.56
Average all lime plots	—	46.7	—	5.62

NIULII MILL AND PLANTATION COMPANY, EXPERIMENT 1, 1922 CROP

Treatment	Value of lime in acid soils		Yield per Acre	
	No. of Plots	Cane	Q. R.	Sugar
2 Tons Waianae lime	8	16.7	8.43	1.92
No lime	8	15.2	8.65	1.80

For greater ease in reference, experiments listed above are herewith given in more condensed form.

LIME EXPERIMENTS

Plantation		Crop Year	Lime		No Lime	
			Cane	Sugar	Cane	Sugar
1. Waipio Substation	0	1916	80.4	11.15	80.1	10.85
2. " "	0 (Residual)	1918	88.0	9.87	84.1	9.29
3. " "	0 (Residual)	1920	66.1	8.37	64.2	8.34
4. Wailuku Sugar Co.	1	1917	86.4	12.40	81.2	12.18
5. " " "	1 (Residual)	1919	74.1	10.87	71.2	10.68
6. Kilauea Sugar Plant. Co..	4	1917	27.2	3.09	25.5	2.94
7. " " " " ..	7	1918	31.9	3.73	31.5	3.69
8. Oahu Sugar Co.	8	1918	67.8	7.25	65.6	7.18
9. Hilo Sugar Co.	18	1921	47.3	5.91	45.2	5.65
10. " " "	18 (Residual)	1923	58.9	6.65	56.8	6.31
11. Hawi Mill & Plant Co. ...	2	1919	54.0	6.86	52.3	6.59
12. Paaupahu Sugar Plant. Co. .	10	1919	46.7	5.62	45.6	5.57
13. Niulii Mill & Plant Co....	1	1922	16.7	1.92	15.2	5.97
14. Kaiwiki Sugar Co.	1	1917	42.1	5.65	40.9	5.67
15. Hamakua Mill Co.	1	1918	15.3	1.93	15.2	1.96
16. " " "	1 (Residual)	1920	26.7	3.53	26.5	3.52
17. " " "	2	1918	11.2	1.34	11.0	1.34
18. " " "	2 (Residual)	1920	20.8	2.63	19.6	2.43
19. Oahu Sugar Co.	17	1918	67.3	6.03	67.6	6.11
20. " " "	17 (Residual)	1920	96.6	13.70	101.6	13.68
21. Grove Farm Co., Ltd.	8	1920	40.7	4.83	41.9	4.98
22. " " " "	8 (Residual)	1922	34.8	4.16	35.5	4.18
23. Kaiwiki Sugar Co.	4	1922	24.5	3.21	24.6	3.39
24. " " "	4 (Residual)	1924	36.2	4.60	34.6	4.33
25. Pepeekeo Sugar Co.	5	1922	49.7	6.45	51.7	6.52
Average			48.5	6.07	47.6	5.97
Average Quality Ratio.....			Lime.... 7.99 No lime.. 7.97			

Since 1916, we have conducted a total of twenty-five lime experiments. These were on all the Islands and covered our various soil types.

In looking over the summary we find that in thirteen of the twenty-five some gains were obtained; in twelve there were no gains from the lime. In practically no case were the gains especially large or significant.

The cane plant would seem to tolerate very wide fluctuations in the lime reaction of a soil. We find very good crops being produced on lands which are almost pure coral; good crops are also produced on soils which are extremely acid, requiring 10 to 12 tons of lime to bring to neutrality. This shows that with us the lime problem is not an especially vital one.

The conditions under which liming would be most likely to give the best returns are on the acid mauka soils which respond to phosphoric acid. Liming such soils would improve conditions for the phosphates and likely tend to an economy in their use.

The average quality ratio of the juices from lime plots was 7.99, while that from the no lime plots was 7.97. We thus see that lime had no effect whatever on the quality of the juices.

Per Capita Sugar Consumption*

Question. What is the average consumption of sugar per person in the United States and how does it compare with that of other countries?

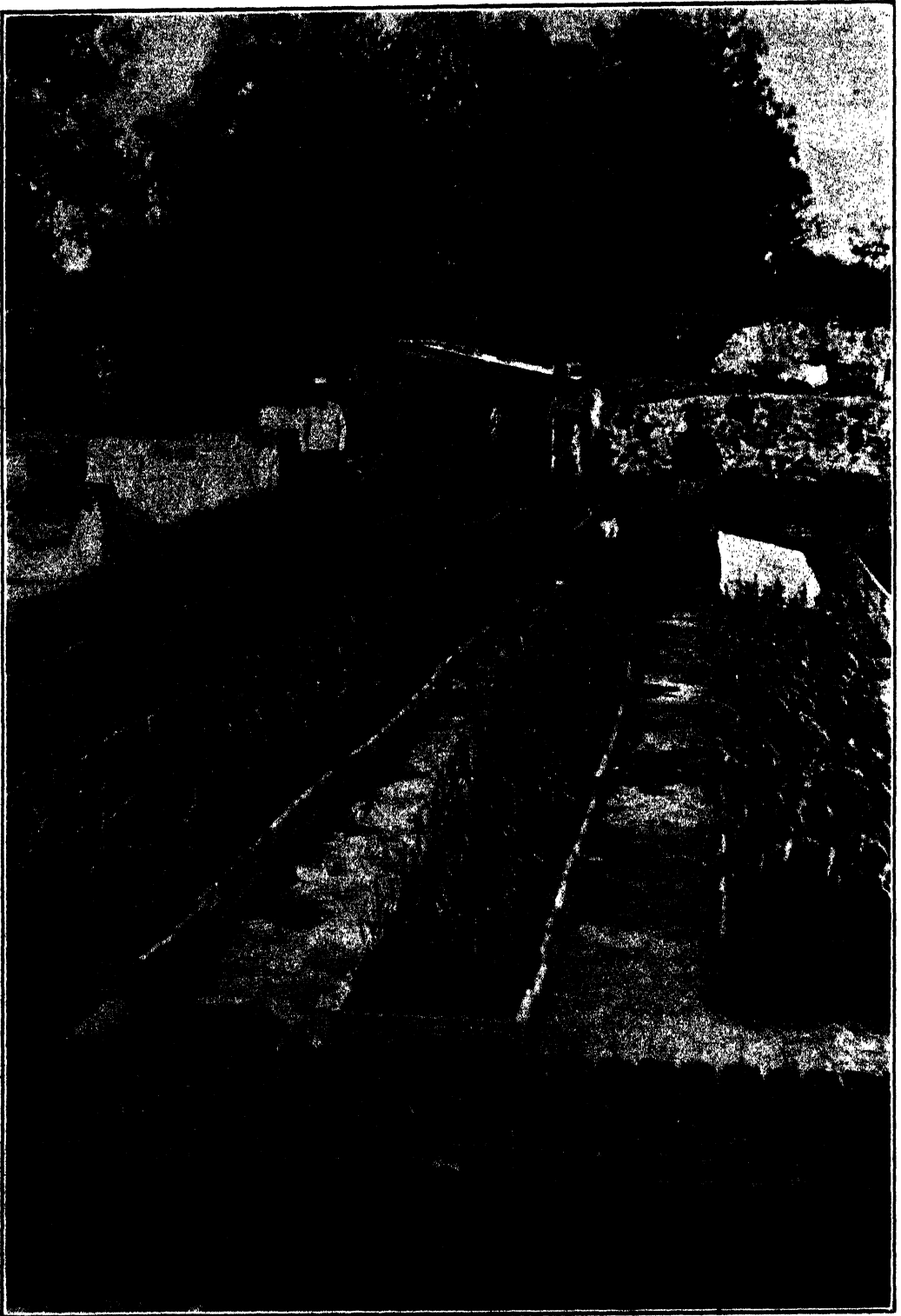
Answer. The average amount of sugar eaten is 2 pounds per person per week, according to the U. S. Department of Agriculture. This includes the sugar used in candies, sweet drinks, and other foods not prepared in the home. The amount of sugar consumed is now higher in the United States than in most other parts of the world, the per capita consumption having increased during the last 100 years from 10 pounds to over 100 pounds.

Country	1913-14 Pounds	1921-22 Pounds
North America—		
United States	89	99
South America—		
Brazil .....	..	20
Argentine .....	..	..
Europe—		
Great Britain	93	70
France	44	35
Germany	45	54
Italy	12	12
Spain	14	17
Russia	25	5
Asia—		
British India	22	20
Japan and Formosa .....	..	15
China .....	..	5

[H. P. A.]

* From The Official Record, U. S. D. A., Vol. III, No. 30.

Seedling Production at Honokaa



A portion of the 20,000 seedlings germinating at Honokaa Sugar Company and Pacific Sugar Mill nursery, Kukuihaele, Hawaii.

Some Factors in Low-Grade Purging Efficiency

By WALTER E. SMITH.

The work of W. R. McAllep at this Experiment Station has shown that sucrose can be crystallized from commercial waste molasses by concentration under conditions similar to those existing in regular massecuite, producing a new mother liquor of lower gravity purity than is ever attained in factory practice. This work shows, therefore, that actual crystallization of sucrose is not the limiting factor in reducing molasses purity to a minimum, but shows rather that the mechanical separation of the crystals from the molasses is essentially the vital factor.

It is a recognized fact that purging of a given low-grade massecuite increases in difficulty with increase in density. When such other contributing factors as grain, temperature, conditions of supersaturation, and viscosity as affected by boiling methods are brought to proper standards as we now know them, density remains as the principal known factor influencing the drying rate, or the rate at which molasses is discharged from the massecuite contained in the centrifugal basket. The point at which reduction of molasses purity by increase of massecuite density ceases to be commercially profitable, is then the point at which the expense of operation and maintenance of the additional centrifugal equipment exceeds the profit of the increased recovery. Similarly, failure to purge at the highest density consistent with the capacity of the equipment available means loss in recovery through increased molasses purity.

Present practice in Hawaii provides equipment sufficient to give capacity for a drying cycle of 45 to 60 minutes; in most cases the purity of the resulting sugar is from 68 to 75, with a few factories able to raise the purity to 78 to 82. Inquiry into the factors of low-grade purging* shows that little, if any, positive data is available as to the actual rate at which the molasses is eliminated from a given centrifugal load of massecuite. The writer has been interested in low-grade purging since it appears that remelt purity is a most important factor in determining the filtrability of commercial sugar, under any given set of factory conditions.

In order to obtain fundamental data on the rate of drying, a number of tests were made by the writer in which the actual rate of molasses elimination was measured. To do this, the molasses was diverted to a tub, by means of a short trough, and weighings made at intervals of 5 minutes over a period of 90 minutes purging. A few minutes was usually required before the molasses actually reached the tub, but it seems entirely fair to regard this latter point as zero, and to offset the time this much, assuming that it takes a few minutes for the flow of molasses to reach the tub, but that it leaves the centrifugal outer shell at the same rate as it is discharged from the basket.

Fig. 1 shows the data obtained from a series of tests at Koloa and Lihue with a 30" belt-driven centrifugal; in the graph, actual quantity of molasses discharged is plotted against time.

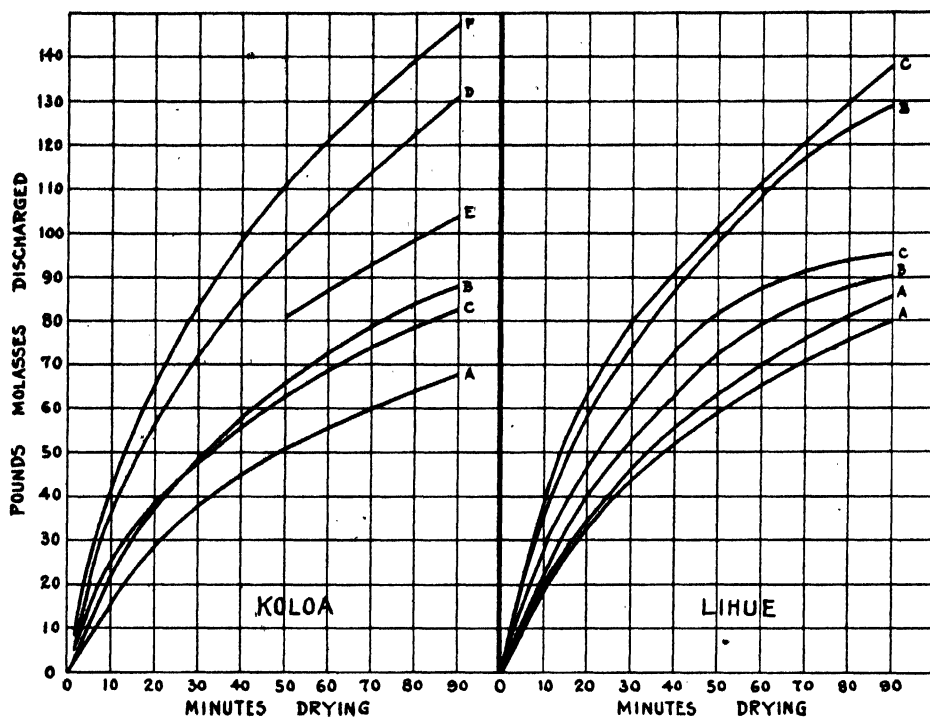


Fig. 1.

In the Lihue series, two tests were made with massecuite from each of three different crystallizers using different quantities in the basket. The following tabulation of data will serve to explain the conditions of the test, as well as the results:

Test	Mass. Brix	Molasses Brix	Quantity of Mass.	No. 2 Sugar Purity	Pounds Molasses 40 mins.	Pounds Molasses 90 mins.	Difference
A-1	96.0	94.8	3.3 cu. ft.	75.2	56	86	
A-2	96.0	94.8	2.0 " "	81.9	53	81	3; 5
B-1	94.8	93.0	3.3 " "	83.4	87	129	
B-2	94.8	93.0	2.2 " "	83.8	63	91	24; 38
C-1	94.2	92.4	3.4 " "	81.3	92	138	
C-2	94.2	92.4	2.0 " "	84.7	73	96	19; 42

The results shown here are very similar to those secured at Koloa, and indicate two general principles:

1. The rate of molasses eliminations tends to increase with reduction of molasses density.

2. At the higher density, with massecuite which would be considered slow-drying, no appreciable loss of efficiency is noted by reducing the quantity of massecuite per load. The difference in molasses elimination due to difference in load tends to increase, however, with the faster-drying massecuites. This condition is also well demonstrated in the Koloa tests, as shown in the following tabulation:

Test	Quantity of Mass.	Pounds Molasses				No. 2 Sugar Purity
		At 40 mins.	Difference	At 90 mins.	Difference	
A-1	2.2 cu. ft.	45	..	68	..	78.0
A-2	2.8 " "	45	0	67	0	73.0
A-3	3.4 " "	46	1	67	0	69.0
C-1	2.4 " "	..	..	83	..	78.0
C-2	3.5 " "	..	..	85	2	69.0
D-1	3.4 " "	85	..	131	..	76.0
D-2	2.6 " "	85	..	116	15	81.0
F-1	3.5 " "	98	..	148	..	74.0
F-2	2.4 " "	..	..	111	37	81.0

These principles would find useful application under a variety of conditions. Suppose, in one case, a factory had ample centrifugal capacity and was able to dry at high density in order to obtain a low molasses. Here the elimination per square foot of screen area would be low, but by reducing the load per machine a higher purity of remelt results without appreciably affecting the centrifugal efficiency. In fact, the rise in remelt purity would probably more than offset the slight loss by reducing the quantity of No. 2 massecuite to be handled, thus increasing the time available for the drying cycle. In another case, suppose a factory has not maintained proper elimination, and to relieve congestion is forced to dilute a crystallizer to low density to speed up drying. Here the greatest molasses elimination will be secured by filling the machines to fullest capacity.

An important condition indicated by the data shown in the drying curves of Fig. 1 is the greater efficiency of the short cycle over the long drying cycle. To compare 30, 45 and 60 minutes on the basis of Test F, Koloa, allowing 5 minutes for discharging, we find the amount of molasses eliminated to be:

Cycle	Drying Period	Pound Molasses Eliminated		% Gain over 60 minute cycle
		(In period)	(In 180 minutes)	
30	25	76	452	30%
45	40	98	392	13%
60	55	116	348	....

In Test A, Koloa, with the slowest drying massecuite, the relative value of the 30, 45 and 60 minute cycle is 127, 113 and 100. In Test B, Lihue, the relation is 130, 114 and 100.

Disregarding for the moment the effect on remelt purity, the short cycle makes possible an increase in centrifugal efficiency which can be used to advantage in drying at heavier density and thus increasing the recovery by lowering the molasses purity. In reducing a one-hour cycle to 45 minutes, if the load is reduced in proportion, the remelt purity will likely remain very much the same, and the elimination per square foot will not be seriously reduced except in the exceptional cases where the massecuite dries particularly well.

It is thus seen that where pan capacity is large, but centrifugal capacity low, the latter may be favored by a reduction of the time cycle, which increases the elimination per square foot of screen area, at the expense of the quantity of low-grade massecuite boiled. On the other hand, where pan capacity is small, but

centrifugal capacity is ample, the pan may be aided by extending the drying time or reducing the centrifugal charge; this will reduce the quantity of low-grade massecuite to be boiled, because of the higher remelt purity, but this assistance will be secured at the expense of the molasses purity, since the elimination per square foot of screen area will be reduced.

In Fig. 2 are shown the graphs of drying tests at several different factories, the rate of elimination being reduced to terms of "pounds per square foot of

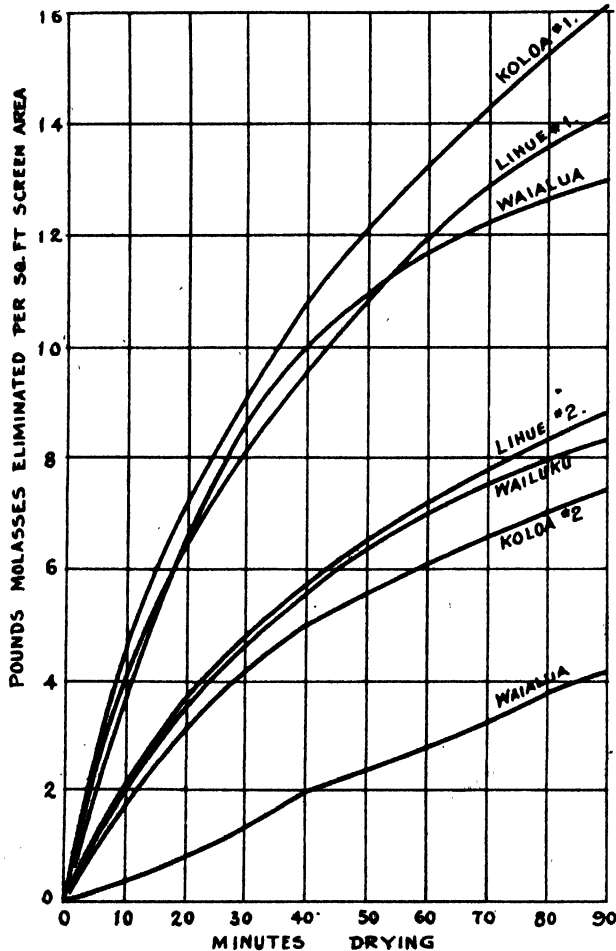


Fig. 2

screen area" to make 30" and 40" machines comparable. Before going further, the writer would call attention to the regularity of the curves in the Koloa and Lihue series. In only one test out of fifteen did one curve cross another; in every other case, once the rate had been established by the flow of the first five-minute period, the curve maintained its relative position and direction with respect to the other tests. In Fig. 2, however, the Waiialua curve shows a tendency much different from the others. During the first 40 minutes it maintains a high rate; at 40 minutes it is only a few pounds behind Koloa, and actually ahead of Lihue. At 90 minutes, however, the Waiialua curve has flattened out and finishes 30 pounds behind the Koloa curve.

A plausible explanation is to attribute this condition to the effect of grain. The Waiialua test was made with a massecuite based on syrup grain, and was

actually most irregular. It is entirely to be expected that the influence of grain irregularity should be shown in such a way as this. The massecuite was very fluid, and so attained a high rate of elimination during the first part of the purging; as the smaller grain filled the interstices between the crystals, the flow of molasses was evidently retarded to a marked extent; an almost identical curve was secured at Waimanalo with a massecuite of practically the same characteristics. A similar, though entirely opposite, effect was shown in a Waialua massecuite boiled on "molasses grain" and characterized by marked regularity of grain and an almost total absence of small grain (0.1 mm.). The curve is not included in Fig. 2, as it crosses other curves at two places and confuses the graphs. In this case, during the first part of the curve it lies below Lihue No. 2 and Wailuku, but maintains its original rate so well that it exceeds the Lihue No. 2 curve by 5 pounds at the end.

SUMMARY

Actual measurement of the rate at which molasses is discharged from massecuite indicates:

1. Tendency for rate of elimination to increase with decrease in molasses density.
2. With slow-drying massecuite, load can be reduced without materially reducing quantity of molasses discharged.
3. Approximately 30 per cent more molasses discharged from two 30-minute drying cycles than with one 60-minute cycle.

Comparative Study of the Cane Varieties, Kavangire, Zwinga and Cayanna No. 10*

By P. RICHARD KUNTZ

(Translated from the Spanish by Z. A. Romero.)

Because of the popularity that the Japanese cane, Uba or Kavangire, has obtained, and in view of the many consultations, personal and by letter, for which the planters of this cane are asking, this Experiment Station has decided to publish this small booklet or pamphlet, in which are established the differences and resemblances, from the agriculturist's point of view, between the cane varieties Uba, Zwinga, and Biloxi or Cayanna No. 10.

The industrial part of this subject is fully treated by Mr. Lopez Dominguez, Special Chemist in Charge of Investigations, in his circular entitled: *The Kavangire Cane and Its Yield of Sugar*.

* Circular No. 73, Insular Exp. Sta. of Porto Rico.

I wish to make clear that the botanical descriptions of the types of cane discussed here are taken from the journal *Sugar Cane Varieties of Porto Rico*, Vol. II, by F. S. Earle.

A period of approximately three years was devoted by Professor F. S. Earle, formerly Expert in Diseases of Cane at this Experiment Station, to the study and observation of mosaic or mottled-leaf disease in Porto Rico. He stated at that time that this disease has been found in all the municipalities of the Islands, except in the Guayanes Valley (Yabucoa). Unfortunately, he now tells us that this disease exists in all sections of the island, including also the small adjacent island of Vieques. The discovery by this same Professor Earle, in the middle of the year 1919, of a variety of cane called Kavangire, completely free from the disease, is a fact of great practical importance. There are now planted in Porto Rico three types or varieties of cane which are completely free of the mosaic; Kavangire (Uba), Zwinga, and the Cayanna No. 10.

It is important that these three varieties be recognized, from the agricultural point of view, as different points affecting their industrial value are constantly coming up; selection should be made in such a manner that the farmer may know what effects may be produced.

UBA OR KAVANGIRE

This cane is erect, very vigorous, tillers abundantly and relatively early. The stem or cane is generally thin, with a diameter of 2 cm.; of a clear green color with a lilac cast, and covered with wax. The internodes are large (10 to 12 or 16 to 18 cm.), cylindrical in shape and sometimes reduced at the base. The nodes are of the same diameter as the internodes. The bandings of the rudimentary roots are somewhat oblique and have sometimes measured from 7 to 9 mm., without color, or yellowish in color. The rudimentary roots are well developed, yellow in color, in three rows in somewhat of an agglomerated arrangement. The buds are obtuse-oval, measuring sometimes 10 x 14 mm., in length extending beyond the banding of the rudimentary roots by one-fourth of its width. The leaves are numerous and abundant, somewhat narrow, 3 cm. in width, with an irregular edge, dentate at the union with the sheath.

The immunity to mosaic disease of this variety of cane has been well established not only by experimental work done here, but also by information from the Argentine and some southern states of the United States. Credit for the introduction of this cane is due Dr. W. May, Federal Director of the Experiment Station at Mayaguez, who brought it in from the Argentine in 1917. By its resemblance to the Japanese orange cane, called Zwinga, it was supposed at the beginning that it also was of Japanese origin and came to be generally known as Japanese. Nevertheless, it seems, according to information published by the Experiment Station at Tucuman, in the Argentine, that this variety is a cultivated one in Japan. It was imported from India to Brazil many years ago; from Brazil it was brought to the Argentine and from there to this island. The authorities on this subject in the Argentine considered it similar to the so-called "Uba cane, which is extensively cultivated in Natal, South Africa, and though this perhaps has not been really confirmed they at least are very similar and have

the same history. This cane ratoons very vigorously and for many years, being also very resistant to root disease and completely free of mosaic. It is a hard cane, very fibrous and consequently is not attacked by the stem borer, but is moderately poor in sugar. This cane matures late and should be cultivated well.

From experiments completed, we have reached the conclusion that the problem to solve is the hastening of the maturity of this cane. I would venture to suggest that experimentation be undertaken to control the maturing by means of applying fertilizer containing more phosphoric acid and potash than nitrogen. And if, in addition, we can control the application of water in the three or four months before maturity, who knows if we should not obtain better results in sugar?

The economic points in regard to this cane are its complete immunity to mosaic, its resistance to the root disease and its immunity to gum disease. It is a cane of high tonnage, and in some cases produces more than ninety tons per acre. Another important point that the Uba has in its favor, is that it grows and gives results in soils in which other varieties do not grow at all well. For example, it might be cited that the majority of the plantations in Anazeo and Aguada, planted to this variety, produced, we are informed, approximately about thirty tons per acre. Its thinness make it cost more for cutting and cartage, but this is offset by its ease of cultivation besides its being adapted to a great variety of soils. With reference to cutting and cartage, I take the liberty of translating the following paragraphs from a report on *The Future of the Uba Cane in Porto Rico*, dated June, 1922. It reads:

Among the many objections given to the Uba cane are the high cost of cutting and transportation by railway. I am of the opinion that the cutting should be done after the burning. It has been demonstrated during the last harvest that by this method said cane can be loaded on cars of the A. R. R. at a cost of 75 centavos to \$1.00 per ton, depending on the prices prevailing for the last crop, without profit for the contractors. With respect to the dead weight of said cane (of great volume and little weight) I have found that, by loading with great care, up to 13 tons of cane can be loaded in a car. If we pay \$1.50 per dead weight, this should be less by 12 centavos per ton for the 13 tons loaded in the car, and I think that the Public Service Commission would take this into consideration and change to 1 to 12 tons as a minimum load per car. Finally, I wish to make clear that I am convinced that the Uba cane can be brought to the factory at a cost of \$3.00 per ton and the production of our lands in the southwestern part of the island will increase, in some places, more than 100 per cent.

Taking into consideration what has been said above, the future of the Uba cane on a large scale in Porto Rico depends strictly upon the factory.

These data are of great value to the planter on a large scale, not only for the Uba cane, but for the Cayanna No. 10, since they are of the same type.

Through the courtesy of Dr. F. S. Earle, Agronomist of the Central Aguirre, we publish, in the following, some analytical data on this cane; the highest figures, perhaps, known up to the present time, giving the conditions, all favorable, under which it was grown, accounting, probably, for these wonderful results.

Uba cane planted in saline and dry fields, on January 27, 1922, germinated and grew well.

ANALYSES OF THE CRUSHER JUICE

Date of cut	Brix	Sucrose	Purity	Age
2-22-23	20.80	17.43	83.8	Young plant, 13 months
2-23-23	19.50	16.75	88.2	Young plant, 14 months
4-16-23	19.30	17.15	88.9	Young plant, 15 months

The author knows of various cases in which this cane was a disappointment because of its low sucrose and purity, notwithstanding having had sixteen months growth and good cultivation; this I must attribute, perhaps, as being due to continuous rain or to its not yet being matured.

ZWINGA

This is another erect cane, very vigorous and a great ratooner, with a long, slender stem (2 cm. as an average diameter) ash-green in color. The internodes are long and completely cylindrical (13 to 15 cm. in length); the nodes are reduced and conspicuous. The rudimentary root bands are much extended outward and from 10 to 12 cm. in width. The rudimentary shoots are well grown, clustered and conspicuous, and are formed in three to four rows. The bud is somewhat oval, measuring approximately 10 x 12 mm. exceeding in length the width of the root band by one-fourth of its width. The leafsheath has some fuzz, especially on the side. The numerous leaves are of a green color, somewhat inclined ($4\frac{1}{2}$ to 5 cm.) and very slightly dentate.

This cane was imported from Louisiana by the Federal Station at Mayaguez. Analyses made demonstrate that it is slower in maturing than the Uba, to which it is very similar, but differs in the abundance of fuzz on the sheath and the protuberance of the nodes. In the Uba the internode and the node are somewhat the same in diameter. Like the Uba, it is free of mosaic and resistant to the diseases of the roots and to gummosis.

As a producer of sugar, this cane has not much value, being slow to mature, and of low purity and sucrose content. In the southern states of the United States it is planted to use as forage for cattle and for the production of honey. It is not very common in Porto Rico, but its similarity to the Japanese cane gave rise to confusion, by planters, between the two varieties.

(BILOXI) CAYANNA No. 10

This is another erect cane, very vigorous and an excellent producer, tillers enough, but not abundantly like Uba cane. The stems are long, slender, $1\frac{3}{4}$ to $2\frac{1}{2}$ cm. in diameter, of a clear green color, like lily leaves, and abundant in wax. The internodes are long, sometimes measuring up to 15 cm., those below becoming more developed than the upper nodes. The nodes are well grown, large, sunken, and measure sometimes 2 mm. in width. The zone or banding of the rudimentary roots is rather wide and grows 10 to 12 mm. and is of a green or mottled color. The rudimentary roots are well developed, with the centers of tobacco color and grouped in three rows. The bud is obtuse-oval, robust, generally measuring 10 x 12 to 14 mm. The skin is of a clear green color, with fine hairs, more on the margins. The leaf or leaf blade is well opened, inclined, $4\frac{1}{2}$ cm. as a general width, of dark green color, slightly dentate toward the base.

This cane has proven to be vigorous, productive and a better ratooner than the Uba or the Zwinga, which it resembles very much. It can be easily distinguished from the other two by the uniform growth of the buds, by the hair that appears on the surface of the leaves, by the robust and well-formed buds, by the fact that germination is subdorsal, while the Zwinga and the Uba are terminal or by the apex. It is more similar to the Zwinga because the two have well-developed nodes and more or less hair on the epidermis of the leaf; but they are easily distinguished by the form of the bud. When the bud is already germinated and begins to form a head, it is always in an erect position, while the Uba stretches and inclines a little. I have observed that the Uba is a little slow to germinate and is therefore tardy in its development and requires as much care and cultivation as any other variety, not succeeding as well as the Cayanna No. 10, with its germination, its uniform and more exuberant development than the Uba and the Zwinga. This is not so when we speak of the ratoons; thus the Uba can ratoon very well, in abundance and with vigor; it is surpassed only by the Cayanna No. 10.

From experiments made by this Station and in the Central Aguirre, this cane has proven to be the best ratooner and to yield more tonnage than the Uba, and, if allowed sufficient time to mature, it would give as much, or perhaps more, sugar per acre as will be seen by the following analyses of the present crop made in the Central Aguirre.

Variety of Cane, Cayanna No. 10. Planted December 29, 1921, with seed brought from the Insular Experiment Station of Rio Piedras:

ANALYSES					
Date	Brix	Sucrose	Purity	Age	
1-20-23	16.55	13.23	79.8	13	months
2-19-23	16.80	13.64	81.2	14	months
3-19-23	17.80	15.13	85.0	15	months
3-31-23	17.40	15.08	86.6	15½	months
4-16-23	18.00	15.60	86.7	16	months

It is similar to the Uba and to the Zwinga in their industrial and agricultural characteristics, so we deduce that it is also free of mosaic, as up to the present time it has proven to be; but no instance is known of its having contracted such an epidemic.

In the Gran Cultura in 1919, Mr. F. S. Earle received some cuttings of cane sent by Mr. S. M. Tracy from the small town of Biloxi, Miss., U. S. A., and, from the letter written by Mr. Tracy which accompanied said seed, is quoted the following paragraph, relative to the name of this cane.

Mr. Tracy says: "I consider this to be the best of the Japanese canes, of which I have many. It is larger and stronger than the others. The manufacturers of syrup of this community, to whom I gave seed, believe that this is the best cane that has been produced for other reasons. I have lost its name and so I call it 'Biloxi'."

This paragraph, without doubt, shows how this cane came to be given its name, but later on Mr. Earle saw in the Experiment Station of Cuba a cane similar to it, which might possibly have been the same, under the name of Cayanna No. 10, so without doubt that is its proper name.

Chemical results were obtained from an experiment made in the Insular Experiment Station with these three varieties of cane; they were planted in rows five feet apart, on the same date (16-2-21) and in the same parcel of land, in plain rich soil, open and well drained, given the same cultivation and only one application of fertilizer 10-10-0 in the plant crop and in the ratoon crop. The analyses of the plant cane were made in the laboratories of the Central Vannina from the mill juice, and the ratoons were analyzed in the laboratories of the Station with a small mill of three rolls driven by a gasoline motor.

ANALYSES OF CANE

Variety	Age	Unc. Brix	Sucrose	Purity
Japanese	Young plant	.....	13.19	85.92
	Young plant	.....	15.82	86.84
	First ratoon	18.70	17.37	90.00
	First ratoon	16.80	15.74	89.43
Cayanna No. 10	Young plant	.....	9.98	72.00
	Young plant	.....	11.56	77.30
	First ratoon	16.10	14.59	87.37
	First ratoon	16.70	15.75	86.89
Zwinga	Young plant	.....	8.81	69.37
	First ratoon	17.70	15.50	84.47
	Young plant	17.50	15.97	87.99

Of these three varieties, that which is grown most in Porto Rico is the Uba, of which there are eight to ten thousand acres*; the Zwinga follows, with scarcely 500 acres. Of Cayanna No. 10 there are some experimental tracts on the island. The Uba cane is fulfilling its mission on the west and north coast, where the mosaic threatens to destroy the sugar industry. Of Zwinga, there remain but 500 acres. Where the epidemic has spread they have substituted, for the local varieties that were infected, the Uba to such an extent that approximately 2,000 acres of it are under cultivation, which, from results obtained in the field as well as in the mill, is proving satisfactory.

Ground Firebrick for Furnace Repair**

By JOSEPH HARRINGTON

In the issue of *Power* of January 3, 1922, the writer described the development of a special monolithic furnace lining that was being worked out by James A. Faulkner, who was then the boiler room engineer at the Cleveland Electric Illuminating Company's Seventieth Street plant. This article treated in brief of the utilization of old firebrick bats which, being ground and mixed with a small percentage of high-temperature cement, constituted the material used in the relining of boiler furnaces. It promised not only to be a great economy, but

* Later information shows this area has been greatly extended.

** *Power*, Vol. 59, No. 25.

involved several interesting phases of high-temperature work. A number of high-set Stirling boilers were relined with this material, with such excellent promise that Mr. Faulkner has since carried the work along commercially to a more extensive degree. It is the result of this later work that should interest combustion engineers generally.

The first result of using old furnace linings that had been partly destroyed was the shortage of old material, and inasmuch as the entire remaining portion of the old firebrick was used without the addition of new material, it early became evident that additional new material would have to be used. This resulted in the development of a plastic bond to be used as mortar in setting up new firebrick walls.

For many years it has been recognized as a cardinal principle in furnace work that the mortar or clay used to form the joints in the brickwork should be of the same chemical characteristics as the brick itself, to avoid having the mortar act as a flux, and in order that its fusing point would be the same as that of the brick. When this basic principle was violated, it was found that the clay joint melted out at a lower temperature than the brick, leaving openings that allowed the furnace gases to attack the brick on more than one face and cause rapid deterioration. Moreover, the clay in its fluxed condition offered opportunity for mechanical attachment of particles of ash blown or lifted from the fuel bed, building up in this way on the side walls a slag deposit that frequently became destructive, the walls suffering when the slag is broken away.

It is almost an ideal situation in which the mortar is made up of the same firebrick as used in the wall itself. Under these circumstances the mechanical and the physical characteristics are identical, and it has been found that a joint so made does not fuse or flux. As a result thicker joints can be made, courses evened up and holes filled in at will without injurious effect and at a much lower expense.

To develop such a product as this, experimentation was required because it had to have a considerable degree of plasticity and at the same time had to set up strongly enough to take the weight and carry the stresses incident to furnace lining. A simple fireclay bond made up of a high-grade clay was not strong enough and had but little plasticity, so that to this base was tried the addition of Portland cement, sodium silicate and other chemicals. Finally a bond that seemed to fulfill all the requirements was developed and it is now being used with success for this purpose.

In connection with the process there developed a mechanical problem that also required attention before it was solved. Hand mixing, no matter how carefully executed, resulted in a sandy product, and when further moistened, the finer parts washed out of the mixture. To render this material permanently plastic, it was found necessary to subject it to the influence of the heavy mullers or wheels of certain familiar machinery used in the preparation of brick. The type of machine is well illustrated in Fig. 1, which also shows a pile of old brickbats removed from furnaces and ready to be ground.

An interesting phase of this work from the financial side, is indicated in the accompanying tabulation, showing the relative cost of brickwork laid up with thin and thick joints.

COMPARATIVE COSTS OF 100 CUBIC FEET OF BRICKWORK.

THIN JOINTS

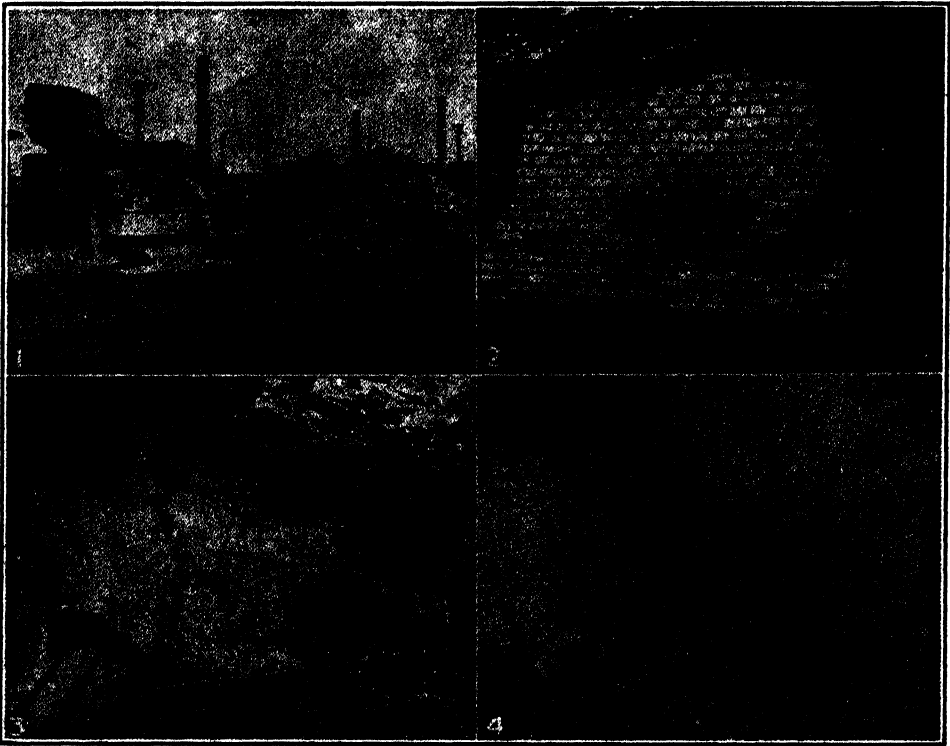
20 bricks per cu. ft.=2,000 brick @ \$50.....	\$100.00
500 lb. h. t. cement per 1,000 brick=1,000 lb. @ 4c.....	40.00
	<hr/>
	\$140.00

THICK JOINTS

100 cu. ft.—15 per cent requires 1,700 brick @ \$50.....	\$ 85.00
1,000 lb. mortar per 1,000 brick=1,700 lb. @ \$7.50 ton	6.38
	<hr/>
	\$ 91.38

A saving of \$48.62, or nearly 35 per cent.

It will be noticed from the table that thick joints in brickwork occupy about 15 per cent of the volume, and when this is made up of a material identical with that of the bricks themselves, the product is in effect a monolithic wall, at least so far as its uniform chemical and physical characteristics are concerned.



- Fig. 1. Wet pan for grinding and mixing the brickbats and special bond.
 Fig. 2. Furnace side wall with heavy joints of special bond.
 Fig. 3. Same wall as in Fig. 2 after seven months' run.
 Fig. 4. Furnace side wall ready for repairs.

Under the former method of relining furnaces when nearly worn out and throwing away the old material, experience shows that an actual wastage of one-third of all the firebricks was suffered. There being room for about 15 per cent of special mortar in the wall, it follows that there will accumulate considerable material unless it is used in quantities for laying up monolithic walls and for similar service, so that there still remains as an interesting phase of the problem,

the ability to utilize the mortar for such work. Also it can be spread over old and partly worn out furnace linings, to which it will adhere and over which it will form a protective coating that can be renewed from time to time with practically no further deterioration of the underlying brickwork. When sufficient material accumulates, the entire bridge wall or possibly an arch can be laid up with this material.

To illustrate, Fig. 2 shows the side wall of a boiler furnace laid up with new firebrick and fairly thick joints. This was a repair job, as evidenced by the appearance of the surrounding parts. After seven months of hard service with practically continuous operation in the vicinity of 250 per cent of rating, the photograph shown in Fig. 3 was taken. It actually shows the opposite side of the furnace, but the conditions were much the same, being satisfactory on either side.

Fig. 4 shows the interior of a boiler furnace laid up in the usual manner before repairs were made. This wall was about ready for complete replacement, but the special material under description was used and laid on with a trowel. It consisted of 80 per cent of old firebrick and 20 per cent of the special bond. The appearance of the wall when the work was finished is indicated in Fig. 5, and Fig. 6 shows the same wall after five weeks' service.

Another side wall that had been in service four months is shown in Fig. 7, and in Fig. 8 a high bridge wall built up as a monolithic structure and photo-



Fig. 5. Side wall of Fig. 4 plastered with refractory mortar without removing old brickwork.

Fig. 6. Wall of Fig. 5 after five weeks' service. Practically unbroken surface.

Fig. 7. Furnace side wall plastered with the refractory mortar.

Fig. 8. High sloping bridge wall of monolithic construction after several months' service.

graphed after several months' service. As indicated in Fig. 9, the bridge wall was constructed by a method similar to that described in the first article in *Power*. Wooden forms were put up foot by foot and the material pounded in place behind the forms, after which the forms were removed and the wall given a slow drying. No attempt was made to smooth up the work.

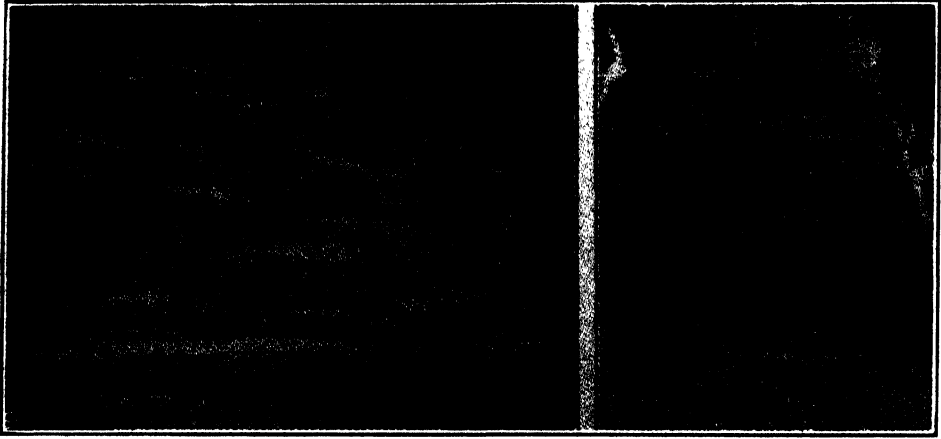


Fig. 9. Method of building bridge wall of Fig. 8 by the monolithic method.
Fig. 10. Patching a side wall with refractory mortar.

A patch in a side wall built up in this way is shown in Fig. 10. It is interesting to note that a large, irregular patch can be applied in this manner and the material pounded in place along the sides to make a joint with the brickwork. Evidently, extensive repairs can be made without any special reference to dimensions or surroundings.

The practical side of these methods lies in their **economy**, secured through a lower cost per cubic foot in both material and labor, **the lessened** loss by radiation and infiltration and the longer period between **repairs**. Anything that genuinely decreases furnace maintenance is worthy of careful consideration.

[W. E. S.]

Experiences in Obtaining Seedlings by Bagging and Artificial Pollination in 1924

By TWIGG SMITH

As an introduction to a resume of our experiences gained during last year's artificial cross pollination of sugar cane I am giving some extracts from *Anatomical and Physiological Studies Concerning Sugar Cane in Cuba*, by Dr. Eva Mameli de Calvino, Chief of the Department of Botany of the Agricultural Experiment Station, Cuba. Bulletin No. 46, April, 1921.

These extracts are particularly interesting as they coincide in most respects with results established here:

The production of varieties of cane by means of the true seed is rather difficult for various reasons.

(1) Because in all tropical and subtropical regions there are many varieties which bloom rarely and there are others that never bloom at all.

(2) Because causes of sterility until now only partially known affect at times the pollen and sometimes the ovaries so that canes reproduced through spontaneous dissemination, i. e. natural field crosses, are very rarely found.

(3) Because plants obtained from seed are very delicate and die easily unless they are taken particular care of.

At the Agricultural Experimental Station of Santiago de las Vegas, in the year 1920, 585 seedlings were obtained, 17 of them by artificial means. To be used for pollinization the cane was cut at its base and carried with its flowers to the female tassel and brought in contact with the inflorescence. In order to avoid quick fading the cane used for pollinization was placed into a can filled with water, and also, the cane itself was changed every three days. The inflorescences under crossing were enclosed in a cage covered with nainsook. In Cuba this method (bagging) protects the pollen and the stigma from the damage caused by the dew which is heavy at the time of blooming of sugar cane.

The crossings of some well known parents are very difficult to obtain in sugar cane, sometimes because of special characteristics of the flower and the variable fertility of its sexual organs, sometimes because the varieties which might cross do not bloom simultaneously. The castration of flowers, the bringing of foreign pollen, the guarding of inflorescences during pollinization have all given rise to the various methods which I am going to describe.

The System of Alternate Rows

In Java there were obtained many seedlings by planting the cane to act as male in alternate rows with the cane to act as female, using as female the Cheribon cane which is said to have sterile pollen. This method has two causes of error: (1) The sterility of pollen of one whole inflorescence cannot be guaranteed except in very special cases. (2) The paternal relationship is uncertain as foreign pollen may be carried by the wind to the stigmas, except where complete isolation is affected. Pollen of sugar cane is very small (42-46 microns) and it can penetrate through any texture of cloth, also the wind can carry it a considerable distance.

Emasculation of Flowers

This method gave very little results. The structure of the cane flower does not permit of careful emasculation without lesions to the stigmas and other organs. From a practical point of view this method does not seem suitable.

Bagged Crosses

Various procedures have been modified to the following: the male tassel is cut, placed in a can of water, so that it is above the one to be fertilized, and both are enclosed in a muslin bag. At 10 a. m. the male tassel is lightly shaken to make its pollen fall upon the stigmas of the female tassel.

Collecting Pollen

Another system is of gathering the pollen in the morning after the dew has disappeared, on sheets of paper, or in small capsules of gelatin. Barber says if the pollen is not very dry it will stick and form heaps which make fertilization difficult and he advised to leave these pollen grains exposed to the sun for some time or to heat them (without indicating the temperature) and to pass them through a piece of cloth and apply with a rubber bulb.

Although Dr. Barber points out that the pollen of *Sacc. spontaneum* will germinate even after two weeks I do not advise drying in the sunlight, heating, or passing through

cloth as temperature, time, and other indispensable precautions cannot be precisely given. Pollen germinates between narrow limits of temperature and humidity, variations in the physical state of the surroundings may harm it, and this explains some of the failures in germination of the flowers of sugar cane after both natural and artificial fertilization.

Crosses Obtained Without Bags

Dr. Barber found that bagging tassels increased the temperature ten degrees over the outside temperature and therefore in India bagging has been discarded for the method of dusting the desired pollen on the stigmas of the chosen female tassel until the stigmas are dry. This method presents the same uncertainties of parentage as the alternate row method for there is no way mentioned of protecting the female tassel from foreign pollen.

Experiments Regarding the Fertility of the Pollen and the Ovary

Numerous works from Experiment Stations in Java and India refer to a method adopted to test fertility of pollen and pistils. The method consists of treating the parts with a solution of distilled water grs. 100; Iodide of potass. gr. 1, iodine gr. 1. If starch is present the parts turn a bluish hue. But that Dr. Barber doubts the universal application of this method can be told from a recent communication of his, a doubt I myself have arrived at in the course of my experimental work. In the communication Dr. Barber says; "The necessity of further studies regarding the value of the experiment as to fertility of the ovaries of the flowerets of sugar cane might be suggested in as far as the presence of starch in the styles is concerned. The discovery of this method was made by Mr. van Katraman but from recent conversation with botanists from Java its universality is to be doubted."

Germination of Seed

The best results in germination were obtained for early tassels; negative results from later tassels. Time of germination 5 to 6 days, in some cases 3, rarely 8 or 10 days. We intend pruning the female tassels, reducing considerably the number of flowers to see if the number of fertile grains is increased.

Critical Examination of the Results

The examination as to starch in the pollen and pistils of cane has compelled the producers of hybrids in sugar cane to examine microscopically the sexual organs of the flowers in order to find the causes of supposed sterility. But it is necessary to point out that some authors at least have established an inexact relation between the germinability and the presence or absence of starch in the pollen and particularly in the styles of many canes. Indeed as can be seen as a result of this study, the presence of starch in the granulas of the pollen is bound to the normal state of the granula itself for the granulas of pollen lacking starch are likewise found to lack all other substances and to be soft. Consequently it is sufficient to find, on examination of the pollen, the presence of the spherical shape and the granular contents; a simple proceeding which also allows the further use of the pollen. As regards the presence of starch in the styles there seems to be according to my observations, no relationship between the fertility of the pistil and starch in the styles, because varieties which, when examined microscopically were lacking in starch in the styles, yet have nevertheless produced fertile pollen both in natural and artificial fertilization. On the contrary some varieties that gave positive results in the observation of starch in the styles produced a sterile seed.

The best conditions of viability and germination of the pollen and the pollinization and the fertility of the pistils can according to my view only be obtained by the observation of the normal morphological organs (spherical pollen full of granulas of starch, ovaries, styles and stigmas that are not aborted or contracted) and this observation alone has practical value.

Conclusions

The methods employed up to the present time of protecting the tassels to guarantee the parentage of the crossings of sugar cane are insufficient. They do not keep out foreign seed, for it penetrates the densest fabrics. Using bags of oiled paper or glass boxes increases the temperature and makes for poor circulation.

It is necessary for each country to study its own conditions of protection, also as regards temperature and humidity.

It seems to me that a glass house in which the work of artificial crossing could be carried on would be of great use, it could be divided in compartments to carry out numerous crossings of different varieties at the same time. By this method the errors inherent to bagging can be avoided, and serious experiments regarding crosses, also the best conditions of temperature and humidity for fertilization can be studied.

The macro and microscopic characteristics of the tassels and descriptions of the different varieties of cane are of the greatest importance both for identification of the varieties, and the selection of better specimens which are to serve in crossing.

The histological study of varieties of cane have revealed noteworthy differential characteristics between varieties and also between closely related canes.

The conditions determining the irregular flowering of cane are unknown. To determine it, it would be necessary to record the relative data as regards temperature, hygrosopicity of the air and soil, etc., during the growing as well as the flowering period.

Pollen from the same variety grown in different places may differ as to its normality.

Pollen of sugar cane does not germinate under common means of cultivation. The stigma of *nicotiana tabacum* was found the best medium.

It is interesting to note that Dr. Eva Calvino, in the paragraph on collecting pollen, says that in Cuba the pollen is collected in the morning, after the dew has disappeared, on sheets of paper, etc.; and under the heading of Bagged Crosses the same writer states that it is their practice to shake the suspended male tassel at 10 a. m. to make its pollen fall on the stigmas of the female tassel.

A very interesting and important point in connection with cross pollination was brought up by Dr. E. W. Brandes at one of the meetings of the Cane Sugar Section of the Pan-Pacific Food Conservation Conference held here August 1 to 14 this year, when Cane Breeding was discussed. As it has to do with the very commencement of the technique of cross pollination of sugar cane I think it can well be placed in this foreword. Speaking on the subject of "Diurnal Variation in Opening of Florets," Dr. Brandes stated that: "As a result of careful observations made at the U. S. Experiment Station on Lake Okichoki, in Florida, it was found that the florets of sugar cane opened up at about 3:40 in the morning, and from that time on until daylight were in the best condition to receive pollen. "Therefore," continued Dr. Brandes, "all our experiments of cross pollination were conducted during those hours."

So far, in Hawaii, we have not made any experiments to ascertain at what hour in the day or night the stigmas of our cane are most receptive. In the method of tying in tassels we have tied them beside the female tassels whenever they were brought in from the field. The time would range from before daylight to dark. By this method we have been able to secure many hundreds of germinations, but it may be that if we are able to establish a period during which stigmas of sugar cane are receptive to pollen and that for the rest of the day they are not receptive, it surely follows that it would be useless to expect results

during the closed period. This would naturally apply to the brushing on of pollen as well as the tying in of tassels. This coming flowering season we will endeavor to find out the receptive period for our varieties and then by actual experimentation see if we can get more germinations by:

(1) Tying in male tassels, freshly gathered, during the receptive period of the stigmas of the acting female variety.

(2) Dusting on pollen, shaken from desired tassels, during the receptive period of the stigmas of the variety acting as female.

METHODS USED IN HAWAII

Inasmuch as the hitherto published experiences in getting known crosses of sugar canes have been more or less outlines of systems used without giving details, I am giving here our experiences of this year in full detail wherever possible.

The plan outlined at the outset in the middle of November, 1923, was very ambitious. We wanted to try conclusively on many varieties the use of the bagging method, both for self-pollination and by introducing foreign pollen. Also the method of dusting or brushing on pollen to the stigmas of varieties that were desirable as female parents. We were particularly anxious to use many varieties as male parent with Uba as female.

With Mr. Kutsunai, I made a very complete reconnaissance of Oahu plantations for about a week in November, during which time we noted the location and condition of the varieties we expected to use.

EARLY TASSELING VARIETIES

Among the first canes to tassel (November) we noted H 109, D 1135 and Yellow Caledonia in nearly every plantation where those varieties are grown. We found Badila at Puuloa, Ewa, Waipahu and Kahuku, but we found it tasseling at Kahuku only. We located Lahaina in Kipapa Gulch and that variety with H 109, D 1135 and Badila were the only ones that were tasseling in sufficient numbers to make it possible to use the tassels in the method of bagging, or collection of pollen for the brushing or dusting method, Yellow Caledonia being one of the varieties that so far has not produced normal flowers. We did not find any Uba in tassel anywhere excepting at this Station.

BAGGING METHOD

We then had bags or cages made to the following dimensions:

Poultry wire of $1\frac{1}{2}$ " mesh and $4\frac{1}{2}$ " wide was cut in pieces 6' 2" long and tied to form a cylinder that was 4' long with a diameter of 2'. This cylinder was strengthened by the addition of No. 6 galvanized wire, one piece threaded perpendicularly with the cylinder and a circle of wire at top and bottom. For the purpose of testing the efficiency of cloth in preventing the entrance of foreign pollen we used three different grades of cotton, one heavy unbleached 90" wide, one of "Harding" cotton 36" wide, a medium weight, and one cheese-cloth, a very light open cloth.

We found that the best way to get the cloth secured around the wire netting cage was to make the cotton into a bag first and slip it over the netting, tying it in a few places top and bottom.

On November 19-20, we erected eight cages at Makiki, five enclosing H 109 tassels and two Striped Mexican. Some days later three were put up over Lahaina and two on Hawaiian canes. We used 15- and 20-foot pieces of 2 x 4 for poles, sinking them 3 feet in the ground and found later in many cases even the 20-foot poles were not high enough. We secured the tassels and bags as much as we figured they would stand without breaking the tassels but the heavy winds commencing on the 26th of November and continuing off and on through December broke down the cages, tassels, and in two cases snapped off the supporting 2 x 4 poles, utterly ruining chances of all these experiments excepting two cages on Striped Mexican tassels. These two were pollinated with H 109 (method described later) and 7 seedlings were germinated. On the 20th of November, we erected 5 cages and on the 26th one more at Kahuku, enclosing two young unopened Badila tassels in each cage. We used three grades of cloth on these six cages, two of thick, two of medium, two of thin. Conditions for a test of the possibility of cloth keeping out pollen were excellent. The Badila tassels enclosed were too young to have received any pollen, they were absolutely unopened, while all around were other varieties in full tassel, their anthers hanging out in a great many cases. The variety H 146, which is very prolific and as a general rule has a great amount of viable pollen, was on the windward side. We had thought of introducing pollen of other varieties into the Badila bags, but the location, 40½ miles from this Station, made it impracticable. As a test of the bagging method this experiment should be very good, as the bags were secured top and bottom and with the exception of being opened slightly occasionally for observations, they were not opened until the tassels were brought in for planting on January 11, 1924. The heavy wind and rain mentioned before had demolished all but three of the Kahuku bags, two of the thinnest muslin bags and one of the thick muslin being saved. Commencing on January 17 and continuing for 18 days we got a steady germination from the tassels from the thinnest muslin bags until 122 were counted. From the thickest muslin bag we got one germination which afterwards turned out to be grass. The seedlings that survived through the transplanting have been planted in an effort to determine whether they are Badila selfs or whether foreign pollen was introduced by the high winds prevailing during the period of enclosure of the tassels.

AN EXPERIMENT TO DETERMINE IF POLLEN COULD PASS THROUGH CLOTH

Prior to using these three grades of cloth mentioned, we collected some pollen of D 1135, placed it in a large-mouthed container and when we inverted the container over loosely held cloth of each grade, the pollen easily passed through to the table below. This proved conclusively that it was possible to pass the pollen through, but we felt that if any thicker cloth than the heavy unbleached were used on the cages there would be a total absence of light, and consequent weakening of the enclosed tassels. Towards the end of December a cage was erected within the Uba x D 1135 windbreak in which we enclosed two unopened Uba

tassels. Several times H 109 was tied in with the Uba tassels and at least twice the pollen of H 109 was dusted on. The heavy windstorms partially wrecked the cage but on January 8, 1924, we planted the remaining Uba fuzz and between January 14 and 20 there were 7 germinations. Of these one was saved and is numbered in the field as U-H 1. At present it is a promising seedling.

• CONCLUSIONS ON BAGGING METHOD

The experiments conducted using cloth covered cages to imprison the inflorescences are not yet completed, as in the case of the Badila experiment we wish to determine whether the seedlings obtained are selfs, or crosses by wind-introduced pollen. Numerically the germinations obtained in the Badila bags were quite satisfactory, and now that they are planted in the field they are quite vigorous.

However, it should be borne in mind that this good germination was from the cages covered with the thinnest muslin through which vagrant pollen could easily pass. The cages covered by thick muslin did not yield any germination, as was also the case with a similarly covered cage on Striped Mexican, the only other seedling obtained by this method being U-H 1, mentioned before.

I do not feel that the trial of the bagging method this year was extensive enough to give us sufficient data to decide absolutely against its use. We were not properly prepared to cope with the high winds that caused so much damage to the erected bags and their contents. However, compared to the use of wind-breaks, the bagging method is very cumbersome.

From our experiment of passing pollen through cloth I cannot feel that there is any guarantee that foreign pollen will not enter the bag.

It is true that in cases as with the thin muslin at Kahuku, large numbers of germinations per tassel are obtainable when using the bags. In fact we had no tassels this year by any means of pollination that compared with the thin bag at Kahuku. So with our conditions at any rate the theory that the enclosing of the inflorescence in bags tends to weaken the germination would appear to be false when the material used is cheese-cloth. Heavy cloth gave no germinations. Dr. Barber, of India, and Dr. Calvino, of Cuba, have very little to say that is good for this method and a great deal against it. In fact Dr. Barber has discontinued the bagging almost entirely, principally because the seedlings obtained were weaklings, due to the excessive temperature in the bag during fertilization. Dr. Calvino finds that none of the methods in use give absolute assurance of parentage and suggests a glass house as the remedy. A glass house could be so arranged that the desired canes to be used as female parents (having previously been grown in pots) could be moved in before tasselling and the pollen-bearing tassels introduced. This method, providing proper allowance is made for ventilation and temperature, should be ideal.

* See article *Extracts from Anatomical and Physiological Studies Concerning Sugar Cane in Cuba* by Dr. Eva Mameli de Calvino in introduction to this article in which Dr. Barber is quoted by Dr. Calvino.

WINDBREAKS

At about the time the wire cages were being made we had windbreaks erected in four widely separated locations at Makiki.

A Description of the Windbreaks: The windbreaks were made of 2 x 4 rough N. W. lumber, used as uprights, with 1 x 3 across horizontally every two feet. They were made what was considered to be sufficiently high above the tassels, about 1 to 2 feet, but next year they will be made higher. We consider now that 5 or 6 feet higher than the highest tassel is not too much, as it keeps the tassels from being wind blown.

Considerable bracing was found to be necessary to make the structure solid on account of the high winds.

This framework was made on three sides only and open at the top.

During a terrific windstorm we put tops on two of the windbreaks, afterwards removing them as the tassels were slowing up in ripening.

The framework was covered with cotton of medium weight and four months after being put up it was in good condition.

Lumber 2 x 12 was placed to form two platforms, one to afford easy access to tie in the "male" tassels and the other, the higher one, so that pollen could be dusted on the stigmas of the female tassel conveniently. Steps were provided to the two levels.

This kind of a windbreak offers no guarantee against the introduction of undesirable pollen by the wind but does protect the female inflorescence and makes the work of artificial pollination by dusting more certain. In this year's efforts we were aided towards certainty in parentage by the location of our cages; also by the fact that Uba, the only cane used as female, was late in tasseling. Again we used as male parents canes, the characteristics of which can readily be recognized in their seedlings. In addition the majority of other varieties had either finished tasseling or the tassels were very old when the Uba experiment was being carried on. If there are any Uba selfed seedlings among this year's seedlings they should be easily recognized owing to the great dissimilarity between the growth habit of Uba and the varieties from which pollen grains were used, H 109, Badila and D 1135.

Varieties From Which Pollen Was Used: Of the four windbreaks three enclosed Uba and one the so-called native or Hawaiian varieties (Manulele, Honuauula and three unknown). The three Uba windbreaks were widely separated and crossed with H 109, Badila and D 1135 respectively. In these three cases we had good success, obtaining germinations from all of them. With the Hawaiian varieties we had no success, as the Manulele flowered but had neither anthers nor stigmas, the Honuauula no flowers, one unknown variety flowered with no anthers and imperfect stigmas, and the rest did not flower. We used two methods of getting pollen to the stigmas of the Uba. We collected pollen and dusted it on and also tied in tassels of the desired varieties. The methods used to collect tassels and pollen will be described under *The Handling of Tassels and Pollen*.

Mending Broken Tassels: In the windbreak where the tassels were within 18 inches of the top we had a great many tassels of Uba bent and some broken off by the wind. That is why we feel that the walls should be at least 5 feet

higher than the tallest tassel. We were able to save most of the tassels, however, by binding splints of split bamboo to the stalk. This had to be done very carefully, winding the string around and around from top to bottom of the splint which was generally about 4 feet long. In cases where the splint was merely tied in three or four places it came loose again and in some cases the tassel was broken in another place.

Bamboo Found to be Best For Tying in Tassels: We made the mistake of using wire stretched from end to end and across the framework hoping that it would support the tassels, and in some cases tying the tassel to the wire, but found that most of the tassels that were broken were snapped off where they crossed the wire, so that method was discontinued. After trying many ways we found that the use of bamboo poles, secured upright, to which the female tassel was fastened, offered the best means of getting the male tassel in proximity, as the can to contain the male tassel could be tied to the bamboo pole also. The platforms were also of great use in changing the water in the cans containing the male or pollen-bearing tassels.

Conclusion on Windbreaks: Next to a glass house where complete isolation of the female tassel can be obtained, I believe this method of using a windbreak to offer the most satisfactory condition for getting quantities of fairly definite crosses.

The element of foreign pollen being blown in by the wind is not eliminated but if care is taken to enclose the cane that is to be used, before the arrows have shown, the chance of definite data is greatly improved. Naturally, it would be unwise to use the pollen of different varieties in the same windbreak.

THE HANDLING OF TASSELS AND POLLEN

As a result of our work of this year I am going into detail about the methods we used and the difficulties encountered in the handling of the tassels and collection of pollen for artificial pollination. Generally it has been stated by writers on this subject that the "male" tassel is cut in the field and placed near the "female" tassel. Dismissing the operation in that manner is permissible if all the minor controlling features are well understood. The methods we used to carry out that simple operation are the ones we adopted after many disappointments and failures.

(1) As the successful cross pollination of cane naturally is controlled by the available material and as cane is very capricious in its tasseling it is well to lay out plans according to the available tassels some time ahead of the season of tasseling, which is very limited.

(2) Having located a sufficient quantity of the desired variety, examine its pollen to determine its viability either by the iodine test, using about 1 per cent iodine to 100 c.c. water to detect the presence or absence of starch, starch being present it will turn brownish black, or by microscopic examination to see if the pollen is spherical and contains granulas, in which case it nearly always contains starch. Neither of the two methods are absolute, but without starch the pollen is not of any use, so perhaps a combination of both methods is best.

(3) There must be some opened anthers as well as unopened or immature ones, proving that it is possible for them to open. In some varieties the anthers

do not open although they hang out on the filament. Young tassels are the best as they have more unopened anthers and therefore offer the best chance to get a quantity of pollen. The riper anthers will very likely be shaken and emptied in transit. A normal anther when it is ready or about to shed its pollen is full, well rounded, with the top opened or about to open. The shrivelled anthers are either emptied or if any pollen is still adhering to the sac it is shrivelled or sticky and of no use.

(4) Cut the stalks long, 10 internodes are not too many. This is absolutely necessary as the life of the tassel depends on it. A young tassel, as in one case with *Badila*, may give pollen for 8 or more days if it is kept alive. Perhaps by cutting an internode a day the life may be prolonged. We did not try that, however. Remove all the leaves clean to the attachment of the sheath. This also helps conserve the energy. If the stalks are to be carried far, lay them out on the ground neatly and wrap up the tassels in flour bags or, better, a piece of 36" wide cloth about 10 feet long. Tie the stalks securely, but not enough to bruise them. Then attach to a strong bamboo pole of suitable length, we used 8', set the butts in a bucket of clean water, and if an automobile is used, place the bucket on the running board and secure it. The bamboo pole, not the cane, should be tied securely to the auto top or sides and it will take off all the jar on the journey. To prevent spilling the water place a loose piece of cloth or a flour bag in the water.

(5) The tassels are to be used either to collect pollen for artificial pollination or to be tied next to a variety that is to be used as the female parent, and thus bring about natural pollination. In either case having arrived at their destination the cane must be cut again higher up the stalk, generally by one internode, while the cane and the cutter are under water, in order that the newly cut stalk will absorb moisture and not air. It does not appear to make much difference to the life of the stalk whether it is left in the same water in which it was cut or shortly after being cut transferred to cleaner water.

(6) As it is the pollen in the unopened anthers that is to be used as it ripens and falls, every effort must be taken to keep the stalk alive. It is absolutely necessary to change the water at least twice a day.

The Dusting or Brushing Method: To collect the pollen for dusting or brushing on the stigmas of other inflorescences we did as follows: The stalks having been cut off by one internode while under water as described were left in the bucket of water and leaned against the edge of a table so that their tassels remained suspended over the table on which black glazed paper had been placed. As soon as pollen showed, generally not before 24 hours, it was swept up with a soft camel's hair brush and placed in a container having an air tight cover. Then as quickly as possible the pollen was taken to the tassel to be pollinated and carefully but liberally brushed onto the stigmas. With a hand lens the pollen can be seen on the stigmas if the operation is successful. To successfully take the pollen the stigmas should have a soft, wet appearance. It is useless to brush pollen on an old stigma. If it is a particularly windy season the operation of pollinating must be protected by some kind of screen in or behind which the operator can work, as the pollen is microscopic and easily blown away. In our

experiments this year we were protected by a windbreak which served the double purpose of protection from wind and pollen of other varieties.

The Method of Bringing Tassels in Contact: With this method of pollination we proceeded as follows: Having cut the cane under water as mentioned before we placed its butt in a bottle or can of water suspending the tassel so that it was above and close to the tassel which was to act as female. It was left there for some days with frequent changes of water and when it appeared too old a new one was inserted. We found that the best way to suspend the tassel was by the use of long bamboo placed so that the two tassels would be together and tied to any convenient fixed object. We used mostly the staging of our windbreak. A number of the female tassels were broken as a result of being tied too tight, or of using wire as a support. There must be some give to the stalk or it will break. A little time spent making it right at first will save a lot of worry afterwards.

Time of Collection: Mention has been made in some articles on the subject that the tassels from which pollen is to be gathered must be gathered early in the morning before the dew has disappeared.

We found as a result of collecting at hours starting from early in the morning, five o'clock and at intervals during the day and late in the evening, that it was possible to get the same amount of pollen regardless of the time of collection. The quantity of pollen yielded by the same variety, but growing in different locations at different levels, and under different irrigation conditions varied considerably. We were able to get plenty of good spherical pollen from D 1135 and H 109 growing at Puuloa which is a very low level, and failed absolutely at the same time with the same varieties growing at Waialua at a high elevation. We feel that another contributing factor is the fact that the cane at Puuloa was being dried off preparatory to harvesting while at Waialua the usual irrigation conditions prevailed.

We feel that this factor of irrigation is a very important one regardless of one contradictory case where a tassel brought in from Waipio and under normal irrigation, yielded more pollen and for a greater number of days than any other variety collected. This tassel was of Striped Mexican and was on the table giving pollen for 10 days. It might be well to add that this tassel was handled in a very careful way. A bucket of water was taken in the field and as soon as cut the tassel was placed in water, and the cut end kept continuously immersed afterwards.

Another place where the effect of this factor of irrigation was noticed was with Badila from Kahuku. For a time although great care was taken we did not get pollen, and later, irrigation being shut off for harvesting, the pollen came plentifully, in one case one lot of 10 tassels yielded for 9 days steadily.

Number of Applications of Pollen: It has been stated by some authorities that it is sufficient to artificially pollinate a tassel of cane three or four times. However, as there are thousands of stigmas on one inflorescence, and the stigmas are not all ready to receive pollen at the same time, the thought is that some chances of pollination would be overlooked so we continued pollinating as long as the stigmas remained moist although generally we were halted by lack of male material.

GERMINATION AND CARE OF ARTIFICIALLY OBTAINED SEEDLINGS OF SUGAR CANE

The time to cut the pollinated tassel of sugar cane for planting cannot be exactly stated in writing. It requires an experienced eye to get the tassel at just the right time. Roughly, however, it may be said that as soon as the very top florets commence to be blown away it is safe to cut most tassels. We planted tassels at many different degrees of ripeness this year and got good results from all of them. We planted tips of tassels that had been broken off and were hanging by merest fibres, apparently dead, and got good germination. The daily record kept by me during the germinating period, shows that one tip, broken off by wind, and planted December 31st gave 8 germinations from January 8 to January 20. Again, one tip broken off by wind, planted December 31, gave from January 8 to January 21, 63 germinations. In fact a summary of the germinations shows that 216 germinations were obtained from broken tips and broken tassels.

Methods Used For Germination: At the beginning of the planting season we invariably placed a layer of black sand about three-fourths of an inch deep in the glass house flats and filled the flats to about 1" from the top with garden soil. Afterwards we changed to bringing the soil flush with the top edges, as in that way the flat received the maximum amount of light and no shadows were cast. With the first mentioned method the first place where green algae showed was always at the edges and it was felt that light would help that condition.

The soil used was a good grade of garden soil, which with the boxes had been thoroughly sterilized.

The tassels were cut and in a protected place stripped of their fuzz which was then laid on top of the soil in the flats and thoroughly wet down. We kept the fuzz very wet the first few days. Here is where the drainage question enters.

It has in previous years been found that the best germination comes when the fuzz is merely laid on top of the soil, not buried or covered. The soil acts as something organic on which germination takes place, the object being to keep the fuzz wet but at the same time have the water drain from the flats. Naturally if the fuzz ceases to be moist germination stops. Towards the end of the season we changed the proportion of the contents of the flats to $\frac{7}{8}$ rock and sand to $\frac{1}{8}$ soil, but as the tassels used were late ones, the fact that we did not get any germinations does not mean that this method is at fault.

We intend using those proportions from the start next year.

As stated before, the heavy winds and generally stormy weather during December and January caused a great deal of damage to the tassels and had we thrown away the broken tips of tassels our total germination would have been cut well below 50 per cent.

Uba as Female Parent: Our experiments this year narrowed down to using Uba as a female parent with D 1135, H 109, Badila, and Lahaina as possible male parents. The experience of last year seemed to show that Uba was an extremely delicate plant from which to obtain germinations. We therefore had a glass house erected and all the Uba tassels were germinated in that glass house. Our first tray of fuzz was placed in the glass house on December 31 and on January 8 the first germination appeared. From then on our troubles began. At first the glass house was simply closed at night, leaving good ventilation, and we got

good germination, then germination ceased absolutely for about one week, and the tiny plants which had germinated began to show signs of weakness.

Green algae commenced to appear and later a few of the plants seemed to be attacked by a leaf disease which manifested itself first by the tiny leaf curling inwardly and then dying gradually from the tip of the leaf in.*

There were, however, none of the usual symptoms of damping off, that is, where the stalk becomes weak just above the soil and topples over.

Heating the Glass House: It was suggested that the possible error was in permitting the delicate seedlings to become chilled at night so we tried two methods of heating in an endeavor to hold the temperature at or near the dew-point of the day. Humidity then became our enemy. It became a question of how much ventilation could we have and at the same time maintain the temperature and a low relative humidity. We tried and discarded kerosene heat fearing that the burning oil generated carbon monoxide which would be injurious to the plants. We next installed electric heaters and it was fairly easy to keep the temperature to about 60° F., while it registered as low as 51° F. outside.

The glass house not having been built with the idea of installing a heating system made it necessary to maintain a watch night and day for a couple of weeks during which time accurate records were kept every hour of the temperature, relative humidity and dewpoint. There was no appreciable improvement in germination as a result of this treatment nor was there any less algae formed. In fact I question the advisability of maintaining even a temperature of 60° F. at night by artificial means. It appeared to retard the growth of the seedlings that had germinated, as even with apparently good ventilation it was difficult to keep the relative humidity down. For instance, a checking of the record sheets shows that, on the average, while we started at the closing up time of the glass house with a relative humidity of around 70° it invariably went as high as around 90° by 1:00 a. m. This increase was caused at times by watering, which was necessary from time to time.

I believe the use of a heating system for our local conditions is advisable for only the few fairly cold nights during January, and that the glass house should

* In this connection Mr. Lee remarks:

You may recall that several weeks ago you suggested trying out Bordeaux dust for the control of green algae upon the nursery flats and pots.

Tests made with Bordeaux dust show that the algae are killed off and the effect is permanent for at least two or three weeks. Treatments with calcium hypochlorite were not as successful due to the fact that the hypochlorite did not dust properly and therefore was applied in solution and although the algae were killed the effect was only temporary.

In the tests made with Bordeaux dust on the seedling flats that were tried in the tests in which H 109 seedlings were growing, the dust entirely controlled the algae very effectively and there has been no visible effect of any sort upon the young seedlings themselves.

Without doubt working with this dust new developments and a more exhaustive idea of the possibilities of the dust can be obtained.

be used more as a protection from wind and rain and an aid to germination only. After a fair amount of germination has taken place, say five days after the first germination, I would advise taking the flats outside and treating them like other seedlings germinated from field or natural crosses.

When the algae first appeared we removed several flats, on which some germination had taken place, out into the open. These did not suffer apparently, in fact a few of them are now planted out with the others in fields. For example, we have U-H 4, a hybrid of H 109 and Uba.

At one stage when many of the germinations were succumbing to glass house conditions and the rest were weak and not growing, we moved most of the flats to the open and left them out day and night. We then commenced transplanting to paper pots, figuring that the change of soil and environment might save most of them. A great many were saved, but perhaps two hundred germinated and died without growing appreciably.

Paper Pots: The paper pots referred to were made of a piece of thin roofing paper fastened to form a cylinder. There was no bottom. The best method of filling was found to be cane trash at the bottom for drainage, then one-half soil, and one-half very old stable manure to the top. It is best to bring the soil to the very top as with the glass house flats.

In comparison with seedlings of other parentage and which were germinated in the open, these seedlings of Uba obtained in the glass house were very slow in growth. There was a long period after transplanting to paper pots when they did not change for days. A large percentage of the germinations turned out later to be grass. It was a matter of much speculation for many days as to whether many of the tiny plants were or were not cane. Mortality was high even after transplanting. We had over 500 germinations of which about 80 were grass. We saved and have planted 114, the rest died either in the glass house flats or after being transplanted to paper pots.

At one time, in an effort to control green algae, we used tar paper as mulching paper in the paper pots. This was not successful, the heat germinated under the tar paper caused the tiny plants to wilt at once, a condition very similar to damping off. The plants all revived after the paper was removed. Perhaps the biggest factor in hastening the development of the seedlings was the use of nutrient solutions, as follows:

0.328 grm. calcium nitrate to 1 litre distilled water,
10.0 grms. calcium phosphate to 1 litre distilled water,
Each application was 10 c.c. calcium nitrate solution and 5 c.c. calcium phosphate.

This was applied at weekly intervals to all seedlings with good results.

SUMMARY

We proved undoubtedly that the good germinations come from the early tassels; in fact, from tassels planted after the middle of January, we did not get any germination, although several varieties were still capable of giving pollen which apparently was viable. This condition makes it necessary to concentrate on the early tassels, November and December.

Throughout the whole operation of obtaining seedlings by artificial means the greatest care and attention are necessary.

From the time the fuzz is ready for planting to the transplanting in the field some one must be constantly on the watch for any slight change.

A constant search for insects must be kept up at all times.

We have recorded the appearance of each of the seedlings, plus a photograph of it, at transplanting time, and will continue to add field notes from time to time to see if the peculiarities of the young plants carry through to maturity. Also it will be interesting and valuable for selection to find out if there is any relation between width of leaf, method of growth, and whether upright or recumbent, etc., in infant canes, and, later, their sucrose content.

A Preliminary Study of the Pamakani Plant (*Eupatorium glandulosum* H. B. K.) in Mexico with Reference to Its Control in Hawaii .

By H. T. OSBORN

[The native name, Pamakani, has been applied to an introduced plant of the thistle family, which first made its appearance as a weed in the country around Ulupalakua on Maui. Like most plants of the thistle family, it produces an abundance of seeds equipped with sails of fine hair or pappus. These seeds are distributed far and wide by the wind, so the plant spreads over the country with astonishing rapidity. In the vicinity of Ulupalakua, it now covers thousands of acres, to the almost complete exclusion of all other plant life. It is a rank-growing, much-branched plant, attaining a height of five or more feet and forms tangled brakes into which man and stock can penetrate with great difficulty only. It has proven to be quite unpalatable to grazing animals and so has become a most pestiferous weed on the ranch lands. It has spread to the ditch country on windward Haleakala, to Iao Valley on western Maui and to the islands of Lanai, Molokai and Oahu, on each of which it has become thoroughly established. Iao Valley evidently affords conditions very much to its liking, for it has reached high concentration at many points and completely covers steep slopes which previously were quite devoid of vegetation. Its behavior in this locality seems to indicate that it might perform a useful function as a ground cover on some of our watersheds.

This Pamakani is a native of Mexico and was early introduced to the horticultural trade as an ornamental flowering plant. It produces showy, compact clusters of white flower-heads which closely resemble those of the well-known *Ageratum*. Its proper name is *Eupatorium glandulosum*, but it has been offered in seed and plant catalogues under the names *E. adenanthum*, *E. adenophorum*, *E. americanum*, and *E. trapezoideum*. It is now extensively grown as a garden

plant in Bermuda. In Jamaica, it escaped from cultivation many years ago and is now widely distributed over that island.

It is only reasonable to suppose that Pamakani was brought to Maui in the early days as an ornamental plant. The soil and climate evidently fulfilled its requirements and not being restrained by any disease, insect pests or grazing animals, its efficient equipment for spreading and its natural competitive powers enabled it to quickly appropriate to its own use large tracts of land. At the present time, its control on the open range is one of the most serious problems confronting those ranch lands which have been invaded.—H. L. Lyon.]

My attention was first called to the occurrence of the Pamakani plant, *Eupatorium glandulosum* H. B. K., on the islands of Oahu, Maui and Molokai, in a letter dated May 22, 1923, which I received from Mr. H. P. Agee, Director of the H. S. P. A. Experiment Station. Because of the serious results occasioned by the invasion of this plant on certain of the ranches on Maui, he requested that I make a thorough investigation of the occurrence of the plant in Mexico and the extent to which it is troublesome on Mexican ranches and to report upon the possibilities of controlling it in Hawaii. First: By the introduction of parasites along the line used in the control of Lantana in Hawaii. Second: By suppressing it with hardy plants which would have value as forage. This project not to take precedence over the work that I was engaged in at that time.

An herbarium specimen of the plant was sent me from Hawaii together with botanical references to the species as a native of Mexico. The following locality reference from the *Biologia Centrali-Americana*, Vol. II, was given:

EUPATORIUM ADENOPHORUM-SPRENG.

Eupatorium glandulosum, H. B. K.: South Mexico, between Carpie and Gasave, 8200 ft. (Humboldt & Bonpland), Costa Rica, Angustura (Polakowsky).

At the time that I received this letter from Mr. Agee I was located at the Hacienda El Potrero, a sugar plantation about 60 miles from Vera Cruz. I was engaged at that time in various insect studies that might be of value to Hawaii, but mainly in the search for and study of the parasites of the army worm (*Heliothrips*) and of a sugar cane beetle borer (*Sphenophorus incurvens*) and in an effort to secure such parasites for shipment to Hawaii.

A search was immediately made for this plant in the vicinity of El Potrero but nothing closely resembling the herbarium specimen at hand was observed; and, in fact, my first inkling as to the localities and situations in which to search for the plant was made while in Mexico City, in October, when I was shown herbarium specimens at the Museum of Biological Investigations. Several specimens there were labeled as from the barranca of Cuernavaca and one from wet rocky ledges near Guadalajara, Jalisco.

Plants were first located in the field at Cuernavaca, Morelos, in October, and after once seeing the plants growing in the field it has been a very easy matter to locate them if present in any locality visited.

I have been located in, or visited, the following localities in Mexico during the past year. During June and July, I was at El Potrero, Vera Cruz. During the latter part of July, I visited the Hacienda Atencingo, a sugar plantation in the state of Puebla. In August, together with Mr. Van Zwaluwenburg, Entomologist for the United Sugar Companies, I visited several sugar plantations in the state of Colima. From there we went to the Isthmus of Tehuantepec visiting several plantations in the vicinity of Tehuantepec and San Jeronimo. We were back at El Potrero, Vera Cruz, the latter part of August. During September and the early part of October, together with Mr. E. G. Smythe, of the U. S. Bureau of Entomology, I was at Cuernavaca, Morelos; Oaxaca, Oaxaca; Orizaba, Vera Cruz, and at Mexico City. From October 17, until November 8, I was at Cuernavaca. November 12, I left Mexico City for Los Mochis, Sinaloa, spending a few days in the vicinity of Guadalajara, Jalisco, and also stopping off en route at Tepic in the state of Nayarit. I was at the United Sugar Companies, Los Mochis, Sinaloa, during the winter months, returning to the vicinity of Mexico City the first of April, 1924. Since returning to this part of Mexico, Cuernavaca has been visited twice, the first and last weeks of April. A stop was made at Orizaba and at Cordoba, Vera Cruz. A short trip was made in May to the low coastal plain about Vera Cruz, to Alvarado, Tlacotalpan and the sugar plantation of San Cristobal near Cosomaloapam. Two weeks in April and two in May were spent at the Hacienda El Potrero in Vera Cruz. During the past three weeks I have been located at the Hacienda Atencingo in Puebla, the sugar plantation of Mr. W. O. Jenkins, and have also visited Cuautla, Morelos, near by, twice.

My plans in visiting these various localities have been largely made in relation to other projects, and, as it has turned out, for fully two-thirds of the time during the past year I have been in localities in which so far I have not found the Pamakani to be present. The longest consecutive period devoted exclusively to study of the Pamakani and particularly to the insects occurring on it was from October 17 to November 8, at Cuernavaca. From the observations made at this time, however, and from time to time since, it is possible to present the following information regarding Pamakani in Mexico.

I. OCCURRENCE IN MEXICO—LOCALITIES WHERE FOUND

The Pamakani plant has been collected or observed in Mexico during the past year in these localities: Cuernavaca, Morelos, 4,500 ft. elev.; Cuautla, Morelos, 4,200 ft.; Guadalajara, Jalisco, 5,000 ft., and the neighboring Barranca de Oblatos, 3,000-5,000 ft.; Santa Ana and San Marcos, Jalisco, Ixtlan, Nayarit, Tepic, Nayarit, 3,000 ft.; Orizaba, Vera Cruz, 4,000 ft.; Atencingo, Puebla, 3,300 ft.

It does not occur in the Valley of Mexico, 7,000 ft., nor did I find any signs of it in any of the surrounding country or at Carpio, Mexico, 7,000 to 9,000 ft.

It was not found on the coastal plain of Sinaloa in the vicinity of Los Mochis. Neither have I found any of the plants in the hot, coastal plain of Vera Cruz. It has not been found at Potrero, Vera Cruz, 1,800 feet, or at Cordoba, 2,700 feet. In Colima, 1,500 to 4,000 ft., and at Oaxaca City, 5,000 ft., it may quite likely occur, though I did not locate plants at the time I was there. At that time

and when on the Isthmus of Tehuantepec I was not acquainted with the characteristics of the plant and its appearance in the field and might easily have overlooked its occurrence.

The localities in which the Pamakani plants have been found are all in what is known as the *tierra templada* or temperate land of Mexico, and it is reasonable to suppose that they can be found in any favorable situation within this region. They quite likely occur at lower elevations in some localities but in the vicinity of El Potrero, a region with which I am very familiar, I have been unable to find them in any sort of situation at elevations from 1,500 to over 2,000 feet. Hardly 20 miles away at Orizaba, 4,000 feet, they do occur.

The *tierra templada* is that even-tempered intermediate region of Mexico lying in general from about 3,000 to 6,000 feet elevation. The yearly average of temperature is said to be from about 73° to 77° F. and there is but little variation with the seasons. There are two seasons, the short season of moderate rainfall during the months of June to September and the much longer almost totally dry season from October to May. The country in general is mountainous, somewhat sparingly forested on the steeper or higher slopes and with large areas of grass-covered plains and hillsides, which present a barren appearance throughout the dry season. Cactus and mesquite are common in the drier districts. Stony outcroppings are numerous and many deep barrancas or gorges, are cut through the solid rock.

Sufficient rain falls throughout most of the region to produce a crop of corn during the summer months. Most of the valleys are abundantly supplied with water for irrigation from permanent streams and large springs, and here sugar cane, bananas, avocados, corn and numberless other semi-tropical and temperate climate products grow continually.

To a certain extent the district about Orizaba in Vera Cruz differs from the rest of the *tierra templada*. It is in a deep valley on the permanently green and heavily wooded eastern slopes of the mountain of Orizaba, a district of heavy rainfall in the summer and of occasional rainy periods throughout the year.

From the fact that the Pamakani in Hawaii has spread over ranch land, in places, to the exclusion of all other vegetation I naturally considered that it would be found in such places in Mexico, under similar conditions. Such has not proved to be the case.

They have been found only in very restricted areas and always in wet places; usually shaded or partially shaded as well. Along small streams they grow in places along the water's edge, usually in small gulches and often clinging to the walls of ledges continuously moistened from seepage or from the spray of waterfalls. Perhaps their habits are most strikingly brought out in their adaptation to more or less artificial situations, such as mill-races, dams, walls, ditches, and aqueducts of masonry construction. In Morelos, there are many irrigation systems, fed by the permanent streams or by large springs. At the sources these are often in barrancas, and where they carry water continuously they are almost certain to be fringed in places at the water's edge with Pamakani. As a rule the ditches are of brick or stone and plaster and in bad condition. The wet places from seepage from the ditches are often also grown up to Pamakani, and where the

water is carried across gulches by the characteristic massive arched aqueducts the plants will be clinging to the outside walls where these are permanently moistened from seepage. Once the ditches are carried out into the open country the Pamakani plants tend to disappear and in the unlined field ditches are superseded by masses of grass and weeds.

The plant does not occur ordinarily along the banks of the larger streams where subject to change of water level, shifting sands, and frequently overgrown with a mass of other vegetation.

In not one single case has a plant been seen in a cultivated field or pasture.

At Cuernavaca, the Pamakani plants were first observed at the end of the rainy season—mid October. At that time plants of various sizes occurred from a few inches up to two or three feet, some bushy plants being possibly of more than a year's growth. None were in flower. At this time the surrounding hill-sides were fast drying up. In addition to the most characteristic localities, plants were observed here growing in some more open situations, roadcuts, stone quarries and walls. On my return in April most of these plants had dried up but some had already flowered and produced seed before their underground source of water failed. Along the streams and ditches and aqueducts the plants were in full bloom on my return in April, and again the last week in April, a time by which the great mass of plants had gone to seed, there was one place, a masonry ditch in a barranca where the plants were still in full bloom and still forming buds.

At Guadalajara, in November, a few partly grown plants were observed along a stream at the edge of town. About five miles distant is the deep Barranca de Oblatos, a canyon a mile across and some 2,000 feet deep. Vigorous clumps of Pamakani were growing along the water's edge in the concrete ditch near the intake for a power plant. Lower down where the canyon widened out and the ditch was more in the open, no plants were growing nor were any found along the edge of the river and some of the small streams running into it at the bottom. In climbing out of the canyon a few plants were found, less than a dozen, in wet spots along the trail and a few clumps at the edge of a waterfall near the rim of the canyon wall. They were not in flower at this time.

At the Hacienda Bella Vista, a sugar plantation at Santa Ana, Jalisco, some 40 miles from Guadalajara, a few plants were found growing along a ditch and also a few clumps clinging to the walls of an old stone quarry.

From San Marcos, Jalisco to Ixtlan, Nayarit, the trip is made on mule back, some 60 kilometers through the mountains, and from Ixtlan to Tepic, Nayarit, by auto stage. At San Marcos, a few Pamakani plants were collected along a rocky stream and boulder fence at the edge of town and a few more observed as we got down into the valley near Ixtlan, and also along the stream bank near town. At Tepic, no plants were growing in the flat cultivated valley about the town. Several miles down stream, however, the valley narrows to a deep gorge. A few plants were observed along a ditch in the grounds of a cotton factory about two miles from town. Farther down, a large irrigation and power ditch is diverted just above a waterfall. Clumps of Pamakani occur along this stone and brick ditch at intervals for a distance of several miles.

At Orizaba, Vera Cruz, no plants were observed along the streams or ledges about town, nor in the valley for several miles above town. A few were observed clinging to the walls of buildings near the main street where these were moist from the spray of a waterfall and clinging to the walls of a viaduct by which one of the main streets is carried over the stream in the center of town. At Escamela, several miles distant from the valley, clumps were growing along an old mill-race and clinging to a stone bridge. In the vicinity of Orizaba, many seemingly very favorable situations for the Pamakani occur but which are occupied with other vegetation. The presence of Pamakani might very easily be overlooked. On the mountain sides above Orizaba, within a few miles, are pine forests, while below, one soon encounters a region of very heavy rainfall with a mass of permanently green vegetation.

At Cuautla, Morelos, the Pamakani is present but in very small amount. While in the same general region as Cuernavaca, it is at several hundred feet lower elevation and in a broad valley. A few clumps of the plant are growing along shaded ditches and on a massive aqueduct about a mile from town. A built-up brick reservoir also had plants growing along the sides and a shaded road with a stone fence and adjoining ditch also harbors some. Another situation with Pamakani is a cut under the railroad, dripping wet from the surrounding irrigated fields. A few were in flower the last week in May, but the tips have since died back. I have not found the plant here along the streams or ditches in the open valley, banks of these being smothered in a growth of grasses, weeds and vines.

Atencingo is an irrigated sugar plantation of some 6,000 acres, in an otherwise barren valley. At Chietla a few miles away, bananas, avocados, and mangoes are also grown. The source of water for the sugar cane is a small river which runs the entire length of the plantation. At the lower diversion dam about a dozen Pamakani plants were growing. At the upper diversion dam just one Pamakani plant was growing at the intake. Along the main ditches Pamakani plants occurred for a short distance in one place where the canal ran along the shaded river bank and again where a main ditch went through a cut some 15 feet in depth. No plants were observed along any of the open field ditches.

Observations were made along the river for a distance of several miles but only in two places were Pamakani plants seen. One of these was near Chietla where the river cuts in under a cliff. The face of the cliff, about 40 feet high, is continuously moist from seepage of the ditches above, and for a distance of a couple of hundred feet the vegetation is largely Pamakani. The other, lower down, consisted of a single clump of a half dozen plants and was growing along the stream on a sand bank in a deeply shaded spot. There was one cluster of flowers at this time, June 1. Apparently Pamakani does not flower freely here, though the observations were made perhaps too late.

Of these places thus mentioned briefly, it is perhaps at Cuernavaca that the Pamakani habitats are most typically represented. This sloping region is cut by numerous deep gorges with many situations favorable for the Pamakani. Even within the limits of the town are springs, streams, aqueducts, and barrancas.

Leaf cutter and twister—About a dozen specimens half grown or more of this caterpillar were collected at Cuernavaca in November. Four or five species of parasites were secured but no adults of the caterpillar. It was observed at San Marcos, Jalisco and Tepic as well. It makes a very noticeable whorl of the cut leaf. I have not noticed it on other plants, than Pamakani.

The leaf-miners, rollers, and webbers appear to me to be well worth more extended investigation.

At San Marcos and at Tepic, a small caterpillar scraping the surface of the Pamakani was observed.

In all some dozen of caterpillars have been collected feeding externally upon the Pamakani in addition to the species more specifically attached to it. Only a few individuals of each, however, were observed and these mostly at Cuernavaca in October and November. A species of bag worm was collected at Cuernavaca in April. Shortly before leaving Cuernavaca in November a species of web-worm appeared. Some half dozen plants were observed with the terminal leaves webbed together by a mass of small caterpillars. A species of *Apion* has also been collected on the leaves.

The leaves are also eaten to some extent by such indiscriminate insects as grasshoppers, several species being collected.

Insects attacking the flowers.

Cecidomyid—common late in April—Cuernavaca.

Trypetid—Cuernavaca, April.

Tortricid—one specimen—Cuernavaca, April.

Snout beetles—Several species were collected in flower heads—Cuernavaca—in April—injury not definite. Common.

Thrips—Several species, Cuernavaca, April. Injury if any not definite.

Capsid—Nymphs and adults, Cuernavaca, April.

The trypetid, cecidomyid and tortricid are definitely injurious in their attack on Pamakani, but the last named was so rare in April as to be almost non-existent so far as importance to Pamakani is concerned.

The trypetid appeared in very small numbers early in April, hundreds of flower heads examined in most situations showing only a few individuals of the fly. One small lot, however, of 350 flower heads showed 30 attacked and another of 150 heads showed 25 attacked. By the last week in April, the trypetid had become more widespread and was found in all of the situations examined. A count of several thousand heads indicated an average percentage infestation of somewhat under 10 per cent. Since a flower head infested by a single trypetid still produces at least half the normal number of seeds, the percentage is still further reduced and when it is considered that it is only late in the season that even this percentage is reached it is seen that the effect of the fly for a season is reduced to a very negligible figure. An actual count indicated an average reduction of the seeds in an infested head of nearly half but this was in a situation also affected by the cecidomyid. An infested head, examined at an early stage shows the partly grown maggots surrounded by a cluster of shrunken seeds. The seeds at this time that are not affected are just beginning to harden and color. The fly develops and pupates in the flower head, the puparium being embedded

endwise into the receptacle where it remains surrounded by a ring of seeds after the healthy seeds have matured and dispersed. The same, or a very similar, trypetid was reared from a related plant at Cuernavaca in September, and in large numbers at Oaxaca in September as well as at Orizaba.

The cecidomyid larvae were observed in Pamakani flowers at Cuernavaca in early April, but had increased very noticeably 3 weeks later. Where only a few individuals are present in a flower very little injury is apparent. They do cause a shrinking of the seeds in the earlier stages and later when 10, 12 or even as in one case 17 are counted in a single head, the effect is quite noticeable. In the case where 17 were in one head not a single sound seed developed. One lot of 50 heads showed 42 infested with 115 cecidomyids, 10 trypetids, 29 hymenoptera. To express the damage by this fly on a percentage basis would be rather more difficult than by the trypetid, it does, however, appear to be of greater importance at Cuernavaca than the trypetid. Similar cecidomyids are common in October on related flowers in the Valley of Mexico.

Tortricid.—Hardly less than 10,000 flower heads were examined in the two trips to Cuernavaca. Just one larva of a tortricid moth, since reared, was obtained. It eats out the developing seeds. The same or a very similar species was found in a related plant flower at Cuernavaca and Oaxaca in October.

Parasites.—A half dozen different species of Hymenoptera were reared out of the Pamakani flower heads. One is a parasite that issued from the pupal stage of the trypetid. Parasite larvae have been observed externally on the cecidomyid larvae and also hyperparasites. One may possibly attack the flower.

Under the conditions at Cuernavaca, the Pamakani plants produce an enormous surplus of seeds so that the very small percentage injured toward the end of the season would hardly seem to be an important factor. If transplanted to Hawaii, the insects would be freed from parasitism but would on the other hand have to breed up during a very short flowering season and would have to survive a long season without alternate plants. All of the insects here mentioned in the flowers also occur as well in related flowers in the late summer and fall at Cuernavaca.

Plant Diseases. Two diseases appearing on Pamakani are here mentioned as noticed at Cuernavaca in October, but it is by no means intended to imply that diseases do not occur. A pathologist would no doubt find a number of fungi and bacteria to attack the plant. No widespread or pronounced disease conditions were noticed, however.

In October, a number of clumps of Pamakani had a "curly leaf" condition similar to the "curly leaf" of sugar beets in appearance and quite possibly likewise associated with one of the species of jassids. The size of the plants did not seem noticeably affected and I am not able to say whether the condition prevents flowering, as it had entirely disappeared in the spring as had the jassids also. Specimens of the diseased plants were sent to Honolulu.

Plants. Under the conditions observed in Mexico, Pamakani does not appear to successfully extend itself against other vegetation. While able to grow in association with other plants to a certain extent, the tendency would seem to be for Pamakani to be crowded out except in situations unfavorable for other plants.

A few plants have been observed on stream banks where there is some grass but never out in open pasture or range. Lower down where ditches are overrun by grasses, Pamakani appears unable to get a foothold. In one place in Cuautla, a cut under the railroad is made in the middle of an irrigated field. This field is continually moist and the beans and corn planted there at present are almost swamped with cosmopolitan weeds and grass. Clinging to the dripping walls of the cut were flowering plants of the Pamakani. At the top and in the field only a few feet away not a single Pamakani plant could be found.

Thus, while in a general way it can be said that Pamakani is to a certain extent repressed by other plants, at the present time I am not able to point out any one plant which I could definitely say represses Pamakani here, is suitable or safe for introduction to Hawaii, and which at the same time could be predicted as likely to suppress or aid in suppressing Pamakani under the conditions in Hawaii.

IV. CONTROL IN MEXICO

That the Pamakani is under great restraint in Mexico, as compared to Hawaii, is evident. The relative value of the different factors involved in this control is perhaps not so evident. One very important point, however, in explaining this control in Mexico, it seems to me, is the nature of growth of the plant together with the climatic conditions, a combination which tends to restrain Pamakani to within very limited habitats.

The Pamakani plant is of relatively slow growth and flowers only in spring at the end of the dry season. At the end of the short rainy season the plants are immature or at least do not produce flowers. Any plants not in protected situations or situations which hold a certain amount of moisture dry up before being able to produce flowers. While the plants in favored situations produce large numbers of seeds, this production is limited to a very small area. New growth is starting up beneath the old clumps in wet places.

It is quite probable that the seeds are scattered over the dry sections and at the end of the rainy season a few places not permanently moist had plants. However, they either do not germinate, or fail to compete if they extend to grass lands or sections already occupied by fast-growing weeds. I have not found any plants coming up in such situations yet this present rainy season. (I am planting some seeds in various situations for observation.) The seeds must also be carried to the irrigated and cultivated fields. That a plant of this character would not even get started is not so plain. Either the conditions for germination are not suitable or they are crowded out at the start in fallowed fields by the mass of weeds and grasses which spring up almost at once.

In the rainier districts such as Orizaba, the plant may be limited to a relatively greater extent by competition with other vegetation.

It has not seemed to me that the control of Pamakani in Mexico has been due to any great extent to the insects and diseases that have been noticed. Still, as I have not seen the plant growing where free from attack, I may possibly underestimate the effect of a retarded growth in the competition with other plants. While a large number of insects have been mentioned and the work of some of

them definitely noted as injurious in character, still the actual abundance of the insects has hardly seemed large enough to be of any great importance. A larger number occur in the more open situations. In favorable situations the Pamakani plants mature and produce seed in spite of the insects. Of one thing, though, I feel quite certain, this past season the seed-infesting insects were of no importance in suppressing Pamakani.

V. POSSIBILITIES OF CONTROL IN HAWAII

First—By the introduction of parasites along the line used in the control of the Lantana in Hawaii.

While not perhaps of prime importance in Mexico, being themselves held in control, it is reasonable to expect that any insect introduced into Hawaii would increase to a great extent; such was the case in the introduction of the lantana insects. If only those insects already noted (and the list is by no means complete) were introduced into Hawaii I feel quite sure that the Pamakani would be very greatly reduced on the ranches. I doubt if the Pamakani would be very seriously affected in such situations as the Iao Valley and I do not know that it is desired to do so. Unfortunately, some of perhaps most value against Pamakani are not considered suitable for introduction.

The various leaf-feeding caterpillars, by defoliating the plant would at the same time give the grass a better chance to grow and make condition for new growth of Pamakani unsuitable. The sucking insects mentioned would greatly stunt the plants. Until the food plant range of each of these insects is much better known, however, it would not be advisable to consider their introduction.

The following general list of insects is perhaps more specifically attached to Pamakani and is suggested for further consideration: the stem and tip borers, leaf-miners, gall insects, the leaf-cutters and rollers and the tip webbers. Each of these is definitely injurious to the plant and a combination of them if able to multiply unchecked ought to be of value in Hawaii, though they could hardly be expected to so completely suppress the plant as the first two groups (defoliators and sucking insects) mentioned.

The flower insects are perhaps worth trying, though the ability to bridge over the long season without flowers is doubtful.

The insects referred to as the trypetid stem gall and the leaf-cutter and twister are distinctive in their work and have not been noticed on other plants, and their introduction to Hawaii would seem to be reasonably safe. The trypetid in the flower heads is ~~also~~ probably safe for introduction. The shipment of the two trypetids would be quite a simple matter.

In considering the introduction of insects to control a pest of importance to only a part of the Territory, the risks should be particularly emphasized. I feel that there is little danger that the insects mentioned would attack the main crops of Hawaii: sugar cane, pineapples and bananas. It is very hard to say, however, that they would not attack such plants as some of the garden ornamentals, or forest shrubs. It is for this reason that I think the insects should be more extensively studied before any introductions.

Second—By suppressing it with hardy plants which would have value as forage.

While it seems true that in Mexico the competition with other plants is perhaps of greater importance than the attack by insects, this appears to be due at least in part to conditions that would not hold in Hawaii, and to a large extent to plants not suitable for introduction. I take it that plants acceptable for introduction on the range would be limited pretty closely to species of grass. Some of the species of grass native to Mexico might be suitable for the ranges in Hawaii. It is a question that I would not feel qualified to decide. That they could be introduced without any assurance that they would spread and crowd out Pamakani seems to me to be very doubtful. The introduction, trial and experimentation with plants of known forage value with the idea of improving range conditions is, I believe, already being done. Some of these may prove of value against Pamakani. I doubt if anything more would be accomplished by seeking for a plant specifically to suppress Pamakani.

In conclusion, it would seem to me that of the two suggestions made for the control of Pamakani, the first offers the more definite chance for success; that if the Pamakani plants are stunted by insects, which seems very feasible, the grasses already occurring there will be grown more vigorously, producing a condition under which Pamakani would tend to be suppressed. A rather slight checking of Pamakani might be sufficient to bring this about.

In case it is decided to continue the investigation of Pamakani with an idea of controlling it by insect introductions, I would recommend that at least three months be spent continuously in some such locality as Cuernavaca, Morelos, the time to be devoted to the study of the insects already observed and any others that might appear, especially as to their range of food plants. From the middle of August until the middle of November would be a suitable time.

It would not be necessary to remain there during the winter months and might be advisable to investigate the Pamakani at that time in Central America.

I would prefer to postpone any shipments of insects to Hawaii until they have been more continuously studied.

(From a letter received from Mr. Osborn dated July 6, 1924.)

The following localities may be added to the list for Pamakani. The mountain slopes above Cuautla, Morelos. The highest point definitely noticed was where occasional clumps occurred in the railroad cuts between Nepantla and Tlacotitlan in the state of Mexico at 6,800 feet. They no doubt occur in favorable and sheltered spots on this the south slope of the mountains to somewhat higher elevations in this locality.

There are a number of rather favorable Pamakani situations not previously noticed near Cuautla but I still consider Cuernavaca as offering the better opportunities for study. The higher elevations can be reached just as conveniently from there.

In reading over the Pamakani report there is one point concerning the plant growth that I perhaps did not make quite clear. At the end of the rainy season last year, plants plainly seedlings from several inches to a couple of feet in height

were collected and included in the plant specimens sent to you. The larger clumps, however, appeared to be of more than a year's growth, perhaps several. At this time of year in very favorable spots I find a very few small seedlings which I take to be Pamakani. The bulk of the new growth though is the shoots from the base of the old clumps and branches from the stems. At the end of the flowering season the tips bearing the flower clusters wilt back but the main stalk does not die, though eventually the old stems would tend to be crowded out by the new branches and shoots.

You may perhaps have some information as to how long the plants persist in Hawaii.

In making recommendations these points were considered. In fact that is one of the reasons why the seed insects appeared to me to be of so little importance here in Mexico.

I found one plant yesterday with a flower cluster of a dozen heads. A very rare occurrence at this time of year. A few of the insects not noticed since last fall are showing up again.

Clarification

Characteristics of Clarified Juice at High Temperatures

By H. F. BOMONTI and W. R. McALLEP

This investigation was undertaken to obtain information on the changes in hot clarified juices, and to define, if possible, what, from the standpoint of raw cane sugar manufacture, may be termed a neutral point or zone. This may be defined as a reaction or range of reactions under which sucrose is not inverted and glucose is not destroyed, or if these changes take place at all, they proceed slowly enough so that their effect is negligible. Micro-organisms can develop and destroy both sucrose and glucose under any conditions of acidity or alkalinity practicable in raw cane sugar manufacture. Previous work in this laboratory has defined the upper limit of bacterial growth in juices as 160° to 165° F. In the absence of germicides, losses of glucose and sucrose are probable, below this temperature. Consequently this investigation has been confined to temperatures above 165° F.

Definite information on destruction of sugar and the conditions governing it, at temperatures above where bacterial action is a factor, is necessary if losses are to be reduced to a minimum and factory operations carried on efficiently. Similar information on destruction of glucose is also important, though loss of glucose is less serious than loss of sucrose.

In the beet sugar industry, information satisfactory from an operating standpoint has long been available. Here the problem is comparatively simple. Glucose is purposely destroyed in one of the first steps of the process. With the glucose originally present destroyed, a qualitative test showing the presence of glucose is

sufficient to detect even very small losses of sucrose through inversion. With the danger point thus easily located, but little uncertainty exists as to the reaction at which a material amount of inversion will be encountered. Further, in the absence of glucose, there is no objection to operating at a moderate alkalinity. The juices are usually maintained sufficiently alkaline so there is a good margin of safety and material losses through inversion in beet sugar factories are rare.

In a cane sugar factory detecting inversion of sucrose is more complicated. The glucose content of the entering juice is constantly changing and further changes in the glucose content take place during clarification. Under such conditions instead of a simple qualitative test ~~being~~ adequate, the most accurate control and analytical methods are necessary to detect even material amounts of inversion. Instead of adequate information as in the beet sugar industry, in the cane sugar industry many conflicting theories have been given credence, resulting in much confusion and great diversity of opinion.

A large amount of scientific research has been devoted to sucrose and the reducing sugars commonly classed as glucose in the sugar industry. Hydrolysis or inversion of sucrose, for instance, has probably been studied as much as any single chemical reaction. After so much work it would seem that there should be little uncertainty as to the conditions governing it. By far the greater part of this work however, is not particularly relevant to the question of what is a safe reaction for juices in factory practice, for it has been measurement of the speed of inversion at comparatively high velocities. Other work at lower velocities bears a closer relation to the question, but even this has been done in solutions that in comparison with highly complex solutions such as cane juice, may be termed "pure solutions." Comparisons of reactions in a simple solution with reactions in a complex solution on the basis of total acidity or alkalinity determined by titration are of little value. This is the only basis that has been available in factory practice. If hydrogen ion concentration measurements, instead of titration figures had been available, inversion of sucrose in juices might have been properly correlated with data for inversion of sucrose in pure solutions. Under existing conditions, however, strictly scientific research has not defined for the factory operator, the point where juices may be carried without danger of inversion. For quite similar reasons strictly scientific research has not defined the conditions attendant on the destruction of glucose in such a manner that the information has been directly applicable to sugar factory practice.

Confusion and diversity of opinion, however, are largely the result of observations and investigations on cane juice itself. This is not at all surprising when we consider the loose way in which the terms "acidity," "alkalinity" and "neutrality" have been used, the comparatively large factor of error in methods of sugar analysis and other difficulties attendant on investigation of juices.

The loose way in which "acidity," "alkalinity" and "neutrality" have been used is undoubtedly one of the principal reasons for the existing confusion. Litmus is commonly used for controlling factory operation, while laboratory investigations have usually been on the basis of phenolphthalein titrations. Due weight has not as a rule been given to the difference between these two indicators in translating laboratory investigations and data appearing in the literature to

factory practice. When titrating strong acids such as hydrochloric acid with a strong base such as sodium hydroxide, the difference in end point between litmus and phenolphthalein is very small, almost negligible. In complex solutions such as cane juices, substances termed buffers are present, and due to their influence, titration results show a material difference between the two end points. Actually the range of reactions at which it is practicable to carry juices in a raw cane sugar factory is included between the points commonly termed "neutrality to litmus" and "neutrality to phenolphthalein." Neither coincide with the modern conception of true neutrality. The neutral or end points of litmus and phenolphthalein are at fairly definite hydrogen ion concentrations and thus are in relation to each other, but values obtained by titrating juices with one indicator are not in any definite relation to similar values obtained with the other. Neither can they be translated into terms of hydrogen ion concentration.

Reasonably satisfactory methods for determining hydrogen ion concentration have been generally available for only some ten years, except in scientific institutions. It is only in the last three or four years that such measurements appear to have been applied to the investigation of sugar factory problems. Had hydrogen ion concentration measurements been made in connection with earlier work, much of the confusion attributable to the manner in which acidity, alkalinity and neutrality have been used, would doubtless have been avoided.

Also, in investigations on juices but little attention has been given to a most significant factor: the development of acidity in juices on standing. This renders investigation of changes in juices a most complicated problem. Failure to give it due consideration has undoubtedly led to erroneous conclusions.

The comparatively large factor of error in methods of sugar analysis, previously mentioned, would not be a serious difficulty if a supply of raw material of the same composition were available from time to time. In an investigation on sugar for instance, portions of an original sample may be kept for weeks without alteration. A series of experiments can be made under the same conditions, and the analyses averaged. These averages will reduce the effect of errors in individual determinations and show what actually happened during the experiments with a satisfactory degree of accuracy, even though factors of error in the analytical methods employed are rather large.

With juices the samples begin to alter almost immediately. Also it is hardly probable that any two samples are of exactly the same composition. Differences in the original samples are further accentuated by differences in behavior on clarification and unavoidable difference in clarification procedure, for it is most difficult to exactly duplicate clarification procedure from time to time. This prevents making a series of experiments under exactly the same conditions, and the number of analyses is limited to those that can be made before the samples alter. Reducing the factor of error by averaging analyses is thus of limited application. By grouping experiments made under close to the same conditions changes during the experiments may be averaged, but to secure valid averages in this way a large amount of data must be available. There is little doubt but that changes sufficiently large to be significant from a manufacturing standpoint have not been detected in investigations on juices because of the comparatively large factor

of error in analytical methods and difficulties in securing closer results through averaging analyses. *

In taking up this investigation, one of two courses had to be chosen, either planning the work to obtain a broad general view of what takes place in a clarified juice at high temperatures, or taking up a single phase at a time and studying it in greater detail. Little or no definite information on the changes that take place was available, so it was necessary to adopt the former plan. This investigation therefore is extensive rather than intensive; that is, each sample of juice has been studied at as many different reactions and as many different factors have been determined as the work that could be done before the samples altered would permit, thus providing the necessary foundation for future work in which the work that can be done before the samples alter may be concentrated on more closely defining details. The procedure adopted was to clarify portions of a sample of juice with varying amounts of lime and digest the resulting clarification series for 22 hours, comparing the analyses before and after digestion. It was found that the desired determinations could be made on a clarification series of five members. A comparatively long digestion time was chosen to accentuate changes and to obtain information directly applicable, in factory practice, to the problem of preserving juices over night and during shut-downs.

The procedure in detail was as follows: Juice for most of the experiments was obtained by grinding cane in a small three-roller mill, the bagasse being again passed through once or twice, after sprinkling with water, so the juice would more nearly approximate ordinary mixed juice. Some three-quarters of the samples were from cane grown at the Makiki plots. Clarification procedure in most of the experiments was similar to that used in studying increases in purity. Five portions of juice were limed to different reactions in the presence of the cush cush the juice happened to contain, brought to the boiling point, filtered with kieselguhr, and analyzed. About one liter of each portion was placed in a tightly stoppered copper container, brought to the desired temperature, digested at this temperature in an electric oven for 22 hours and analyzed. The analyses included brix, polarization, sucrose, glucose, titration with phenolphthalein, titration with litmus, and hydrogen ion concentration.

ANALYTICAL METHODS

Brix was usually determined with a hydrometer. The readings were estimated to the nearest hundredth, though .03 to .04 was about as close as they could be made with certainty. In several of the experiments brix was determined with a pycnometer, in which analyses the probable error does not exceed .01 to .02.

Polarization was determined by Horne's dry lead subacetate method.

Sucrose was determined by the Hawaiian Chemists' Association method, using the Walker method of inversion. During the course of this work the sucrose determinations, before and after digestion, were checked with chemical sucrose determinations, to see if the digestion affected the relative results. It was found that any possible changes were too small to be thus detected, and in any case, were small enough to be considered negligible.*

* Record, Vol. XXVII, p. 145.

The factor of error in purities as calculated from these determinations is rather large, a total error of 0.1, which it will be noted may be the sum of the errors in four determinations, two each of brix, and sucrose or polarization, corresponding to approximately 0.7 in purity.

Glucose was determined by the Munson and Walker method. Sufficiently consistent results were not secured by weighing the reduced copper as cupric oxide, so after the first experiment, reduced copper was determined by the thiosulphate method, details of which are in the article referred to above. With careful attention to details and determining the reduced copper in this way, entirely satisfactory results were secured. The maximum probable error in these determinations is about 0.01 per cent and it is improbable that the maximum error in a comparison involving two determinations exceeds 0.02 per cent.

Reaction to phenolphthalein was determined by titrating ten c.c. of juice diluted to 100 c.c. with distilled water, with N/28 sodium hydroxide or sulphuric acid. The end point was not particularly sharp in dark colored juices.

Reaction to litmus was determined by adding N/28 alkali or acid in small portions to undiluted juice, until the end point was passed. After each addition, a drop of the juice was placed on a strip of non-absorbent, sensitive litmus paper. After the last addition the drops were shaken off, leaving a row of spots, graduated in color from pink to blue. The end point can be determined with a high degree of accuracy even when titrating very dark juices. Reaction to both litmus and phenolphthalein are expressed as per cent CaO.

Hydrogen ion concentration was determined with a Hildebrand type of hydrogen electrode and a one-tenth normal calomel cell. Figures for hydrogen ion concentration are unwieldy, so for convenience the results are expressed in pH values. The pH value is the logarithm of the reciprocal of the hydrogen ion concentration in grams per liter. Figures lower than seven indicate excess of hydrogen over hydroxyl ions or acidity. Figures higher than seven indicate hydroxyl in excess of hydrogen ions, or alkalinity. Seven is true neutrality, that is, exactly the same concentration of hydrogen and hydroxyl ions.* These determinations were made on samples diluted with three volumes of water to avoid some difficulties encountered when using the hydrogen electrode in undiluted juice. Later work indicates that this dilution may cause a slight increase in pH, between seven and eight, the pH range in which we are particularly interested. This varies from 0 to a maximum of 0.2, and pH values in these data may exceed the actual pH by such an amount.

Though analyses have not been made in duplicate, those for the same experiment are to some extent a check on each other. The clarified juices before digestion form a clarification series. Fairly well defined purity relations and also some information on relative glucose content in the juices in such a series have been developed by previous work. The analyses before digestion in each experiment have been made at the same time and under the same temperature conditions. Also the samples are of common origin. Direct polarization by the dry-lead method under such conditions is subject to a minimum of manipulative error and is of high relative accuracy, though its relation to true sucrose changes with varying amounts of glucose. If the latter is taken into consideration the value for sucrose minus polarization in a series such as we are considering may be used to detect irregularities in sucrose determinations, which are subject to more manipulative error than polarizations. The above is equally applicable to sucrose determinations in the juices after digestion. Unfortunately, there is less of a

* For further discussion of pH values, refer to the Record, Vol. XXVIII, p. 110, and Clark's Determination of Hydrogen Ion.

check on the accuracy of brix determinations, which on the whole are the least satisfactory of the determinations in these analyses. Evaporation during clarification causes irregular changes in density so the brix of juices after clarification are not necessarily in definite relation to each other. Comparisons of brix before and after digestion are of somewhat more value. Even in this case evaporation from imperfectly closed containers can cause an increase in brix during digestion. This happened in a number of instances. Inversion of sucrose also causes a very slight increase in brix. However, a decrease of over a few hundredths during digestion under the conditions of these experiments, can hardly be accounted for except by an error in reading the hydrometer. In three cases comparisons strongly indicate such an error approximating one-tenth degree. Analytical data secured in this investigation have been carefully examined as indicated above. Information so secured has been of great assistance in deciding on the weight to give individual purity determinations.

EXPERIMENTAL DATA

The tables which follow contain condensed data for the different experiments and conclusions with respect to inversion. In arriving at conclusions, glucose determinations have been given greater weight than purities. An increase in glucose during digestion of over 0.02 has been accepted as "positive" evidence of inversion. Inversion has also been considered "positive" when an increase of 0.02 in glucose has been accompanied by decreases in purity and in the sucrose-glucose ratio. Inversion has been considered "probable" where an increase of 0.01 in glucose has been accompanied by decreases in purity and in the sucrose-glucose ratio. In a few instances juices have been designated as "doubtful" because of some indications of inversion which are hardly definite enough to justify the designation "probable."

Significant features of the experiments are pointed out in the comments accompanying the tables. Where the comparisons previously discussed have indicated probable analytical errors having any bearing on the conclusions, this is also noted.

The figures 1 to 5 in the following tabulations designate the clarified juices secured by clarifying the original sample with different amounts of lime, No. 1 being the most acid and No. 5 the most alkaline clarification. The relative amounts of lime are indicated immediately below, the figures referring to cubic centimeters of a lime suspension used per liter of juice. The first of the three columns for each member of the clarification series, designated "before," is the analysis of the clarified juice. The second, designated "after," is the same juice after digestion. Changes that have taken place during digestion are indicated in the third column. In this column dark-face indicates *minus*, and light-face figures *plus* differences. Acidity to phenolphthalein or litmus is in dark-face, while alkalinity is in light-face figures. Figures for reaction, in the third column, refer to changes in the direction alkaline to acid, there being no changes in the opposite direction. S/G is an abbreviation for the sucrose-glucose ratio and S—P is an abbreviation for sucrose minus polarization.

Experiment 1 at 180° F.: This first clarification series covers a wide range of reactions, 1 being neutral to litmus, or slightly on the acid side of true neutrality, 3 neutral to phenolphthalein, 4 and 5 alkaline to phenolphthalein. All of the juices changed in reaction towards acidity during digestion irrespective of whether the original reaction was alkaline or acid. There are increases in glucose of .02 or more accompanied by decreases in purities and sucrose-glucose ratios in 1 and 2. Inversion has been designated as positive. In 3 there is no change in glucose. There is a decrease in gravity purity but as the value for sucrose minus polarization is low in comparison with the other juices after digestion, indicating a slightly low sucrose determination, the purity decrease alone has not been considered sufficient evidence of inversion to class this juice as "doubtful." Juices 3, 4 and 5 have been designated as showing no inversion.

It will be noted that inversion has been detected in 2 at .005 alkalinity to litmus and 7.68 pH after digestion. Inversion has therefore taken place in a juice alkaline to true neutrality. It has not been detected, however, in the more alkaline juices, 3, 4 and 5. At .008 alkalinity to litmus and 8.18 pH is the lowest alkalinity at which inversion was not detected.

EXPERIMENT NO. 1 AT 180°.

	1 3 cc Lime			2 6 cc Lime			3 9 cc Lime			4 12 cc Lime			5 15 cc Lime		
	Bef.	After	Diff.	Bef.	After	Diff.	Bef.	After	Diff.	Bef.	After	Diff.	Bef.	After	Diff.
Brix	13.72	13.85	.13	13.64	13.66	.02	13.68	14.22	.54	13.85	13.83	.02	13.71	13.65	.06
Pol.	12.65	12.57	.08	12.65	12.65	0	12.74	13.23	.49	12.85	12.85	0	12.71	12.67	.04
Sucrose	12.77	12.71	.06	12.77	12.76	.01	12.86	13.31	.45	12.92	12.94	.02	12.78	12.76	.02
Glucose	.06	.24	.18	.06	.08	.02	.06	.06	0	.03	.03	0	.02	.02	0
Apt. Pty.	92.21	90.76	1.45	92.74	92.61	.13	93.13	93.04	.09	92.78	92.91	.13	92.71	92.82	.11
Gr. Pty.	93.08	91.77	1.31	93.62	93.41	.21	94.01	93.60	.41	93.29	93.56	.27	93.22	93.48	.26
S/G	213	53	160	213	160	53	214	222	8	431	431	0	639	638	1
S—P	.12	.14	.02	.12	.11	.01	.12	.08	.04	.07	.09	.02	.07	.09	.02
Phenol	.014	.020	.006	.007	.009	.002	0	.004	.004	.001	.002	.003	.006	.004	.002
Litmus	0	.006	.006	.008	.005	.003	.012	.008	.004	.014	.010	.004	.020	.016	.004
pH	6.86	6.58	.28	8.10	7.68	.42	8.80	8.18	.62	9.11	8.44	.67	9.96	9.47	.49
Inversion	Positive			Positive			None			None			None		

Experiment 2 at 180° F.: Experiment 2 does not cover as wide a range of reactions as Experiment 1, nor is it so alkaline, 1 being slightly acid to litmus, 5 slightly alkaline to phenolphthalein and the other three juices between the neutral points of these indicators. The containers were not closed during this experiment and juice temperatures were probably somewhat below 180° F. because of the cooling effect of evaporation in open containers.

Reactions again change toward acidity during digestion. Juices 1, 2 and 3 show increases of over 0.02 in glucose and decreases in sucrose-glucose ratios. There are also decreases in purities except in 3. Inversion has been designated as positive in all three, comparisons of sucrose minus polarization indicating that the increase of 0.24 in gravity purity in 3 is due to a slightly high sucrose determination in the analysis after inversion. The increase of 0.01 in glucose in 4 corresponds approximately to the increase in density during digestion. In 5 also a similar increase in glucose is partially accounted for by an increase in density. Juices 4 and 5 have been designated as showing no inversion.

EXPERIMENT NO. 2 AT 180°.

	1 2.5 cc Lime			2 5 cc Lime			3 7.5 cc Lime			4 10 cc Lime			5 12.5 cc Lime		
	Bef.	After	Diff.	Bef.	After	Diff.	Bef.	After	Diff.	Bef.	After	Diff.	Bef.	After	Diff.
Brix	14.01	13.97	.04	13.75	13.82	.07	13.60	13.62	.02	13.71	14.00	.29	13.64	13.77	.13
Pol.	11.65	11.18	.47	11.63	11.57	.06	11.57	11.55	.02	11.77	12.00	.23	11.76	11.87	.11
Sucrose	11.80	11.48	.32	11.80	11.75	.05	11.71	11.76	.05	11.84	12.12	.28	11.87	11.99	.12
Glucose	.68	1.08	.40	.67	.76	.09	.64	.68	.04	.63	.64	.01	.59	.60	.01
Apt. Pty.	83.16	80.03	3.13	84.58	83.72	.86	85.10	84.80	.30	85.85	85.71	.14	86.22	86.20	.02
Gr. Pty.	84.22	82.20	2.02	85.82	85.02	.80	86.10	86.34	.24	86.36	86.57	.21	87.02	87.07	.05
S/G	17.35	10.63	6.72	17.61	15.46	2.15	18.30	17.29	1.01	18.79	18.94	.15	20.12	20.00	.12
S-P	.15	.30	.15	.17	.18	.01	.14	.21	.07	.07	.12	.05	.11	.12	.01
Phenol	.042	.051	.009	.032	.031	.001	.016	.016	0	.002	.012	.010	.002	.008	.010
Litmus	.004	.008	.004	.003	.002	.005	.008	.003	.005	.011	.005	.006	.014	.012	.002
pH	6.24	5.99	.25	6.78	6.41	.37	8.18	6.86	1.32	8.55	7.25	1.30	8.69	7.84	1.35
Inversion	Positive			Positive			Positive			None			None		

Experiment 3 at 180° F.: The cane in Experiment 3 was allowed to lie on the ground for three days after cutting. The clarified juices were slightly less alkaline than corresponding juices in Experiment 2. All juices changed in reaction towards acidity. Inversion is positively indicated in juices 1, 2, 3 and 4 by increase of over 0.02 in glucose accompanied by decreases in purities and in sucrose-glucose ratio. Inversion has been designated as "probable" in 5. The least alkaline juice in which inversion was positively detected, 4, was .010 alkaline to litmus and 7.25 pH, with probable inversion in 5 at .012 alkalinity to litmus and 7.51 pH.

EXPERIMENT NO. 3 AT 180°.

	1 2.5 cc Lime			2 5 cc Lime			3 7.5 cc Lime			4 10 cc Lime			5 12.5 cc Lime		
	Bef.	After	Diff.	Bef.	After	Diff.	Bef.	After	Diff.	Bef.	After	Diff.	Bef.	After	Diff.
Brix	15.47	15.45	.02	15.42	15.40	.02	15.42	15.43	.01	15.33	15.32	.01	15.43	15.42	.01
Pol.	13.10	12.70	.40	13.19	12.89	.30	13.25	13.21	.04	13.21	13.17	.04	13.37	13.36	.01
Sucrose	13.32	13.04	.28	13.39	13.17	.22	13.44	13.39	.05	13.42	13.37	.05	13.58	13.54	.04
Glucose	.60	.91	.31	.59	.81	.22	.58	.63	.05	.56	.60	.04	.51	.52	.01
Apt. Pty.	84.68	82.20	2.48	85.54	83.70	1.84	85.93	85.61	.32	86.17	85.97	.20	86.65	86.64	.01
Gr. Pty.	86.10	84.40	1.70	86.84	85.52	1.32	87.16	86.78	.38	87.54	87.27	.27	88.01	87.81	.20
S/G	22.20	14.33	7.87	22.70	16.26	6.44	23.17	21.25	1.92	23.96	22.28	1.68	26.63	26.04	.59
S-P	.22	.34	.12	.20	.28	.08	.19	.18	.01	.21	.20	.01	.21	.18	.03
Phenol	.042	.045	.003	.028	.036	.008	.015	.022	.007	.008	.014	.008	.000	.008	.008
Litmus	.006	.008	.002	.002	.001	.003	.006	.006	0	.014	.010	.004	.018	.012	.006
pH	5.98	5.90	.08	6.61	6.32	.29	7.51	6.91	.60	8.27	7.25	1.02	8.64	7.51	1.13
Inversion	Positive			Positive			Positive			Positive			Probable		

Experiment 4 at 180° F.: The cane in Experiment 4 was part of the sample used in Experiment 3, ten days after cutting. In this time the cane had deteriorated, the purities being much lower and glucose much higher than in the preceding experiment. With approximately the same amounts of lime used, juices 1, 2 and 3 are considerably less alkaline than corresponding juices in Experiment 3. Juices 4 and 5 are also less alkaline to phenolphthalein but are close to the same litmus reactions and pH values as corresponding juices in the preceding experiment. Deterioration appears to have made considerable changes in the relative values of litmus titration, phenolphthalein titration and pH.

Juices 1, 2, and 3 show positive inversion. Juice 4 has been classed as "doubtful" on account of moderate decreases in purities though no increase in glucose is indicated. Number 5 shows no evidence of inversion; on the contrary, there is a decrease of 0.02 in glucose. This is the only instance in these experiments where a fairly definite indication of destruction of glucose during digestion is found. The least alkaline reaction at which inversion is positively shown is .002 acidity to litmus and 6.15 pH with possible inversion at .004 alkalinity

to litmus and 7.22 pH, while the least alkaline reaction showing no inversion is .010 alkalinity to litmus and 7.59 pH.

EXPERIMENT NO. 4 AT 180°.

	1 2.5 cc Lime			2 5 cc Lime			3 7.5 cc Lime			4 10 cc Lime			5 12.5 cc Lime		
	Bef.	After	Diff.	Bef.	After	Diff.	Bef.	After	Diff.	Bef.	After	Diff.	Bef.	After	Diff.
Brix	14.90	14.92	.02	14.93	14.94	.01	14.79	14.77	.02	14.64	14.66	.02	14.72	14.72	0
Pol.	9.70	8.95	.75	9.91	9.33	.58	9.85	9.64	.21	9.80	9.75	.05	9.85	9.86	.01
Sucrose	10.17	9.60	.57	10.36	9.94	.42	10.27	10.14	.13	10.20	10.15	.05	10.28	10.28	0
Glucose	2.64	3.29	.65	2.63	3.05	.42	2.60	2.74	.14	2.58	2.58	0	2.55	2.53	.02
Apt. Pty.	65.10	59.99	5.11	66.38	62.45	3.93	66.60	65.27	1.33	66.94	66.51	.43	66.92	66.98	.06
Gr. Pty.	68.26	64.34	3.92	69.39	66.53	2.86	69.44	68.65	.79	69.67	69.24	.43	69.84	69.84	0
S/G	3.85	2.92	.93	3.94	3.26	.68	3.95	3.70	.25	3.95	3.93	.02	4.03	4.06	.03
S-P	.47	.65	.18	.45	.61	.16	.42	.50	.08	.40	.40	0	.43	.42	.01
Phenol	.063	.067	.004	.044	.050	.006	.028	.035	.007	.012	.025	.013	.004	.016	.012
Litmus	.010	.014	.004	.002	.007	.005	.002	.002	.004	.012	.004	.008	.018	.010	.008
pH	5.90	5.73	.17	6.15	5.99	.16	6.49	6.15	.34	8.25	7.22	1.03	8.60	7.59	1.01
Inversion	Positive			Positive			Positive			Doubtful			None		

Experiment 5 at 180° F.: Experiment 5 is a more alkaline series, all of the initial juices being alkaline to litmus and three alkaline to phenolphthalein. Inversion is positively indicated in 1 by an increase of 0.04 in glucose and decreases in purities and the sucrose-glucose ratio. Inversion has been designated as "doubtful" in 2 and 3 on account of small increases in glucose and decreases in sucrose-glucose ratios. Figures for juice 3 show increases in apparent and gravity purity during digestion. Comparisons do not indicate irregularities in polarization or sucrose determinations but do indicate a decrease in brix during digestion. This, as previously noted, is hardly to be accounted for except by an error in the brix determination. Initial purities are normal in comparison with initial purities in 2 and 4 locating the error in the analysis after digestion. Increases in purity in 3 are undoubtedly due to a minus error of approximately .1 in determining brix after digestion.

No increase in glucose or other evidence of inversion is shown by the analysis of juices 4 and 5.

The least alkaline reaction at which inversion was positively shown was .002 alkalinity to litmus and 7.25 pH, while the least alkaline juice showing no evidence of inversion was .007 alkaline to litmus and 8.01 pH.

EXPERIMENT NO. 5 AT 180°.

	1 10 cc Lime			2 12.5 cc Lime			3 15 cc Lime			4 17.5 cc Lime			5 20 cc Lime		
	Bef.	After	Diff.	Bef.	After	Diff.	Bef.	After	Diff.	Bef.	After	Diff.	Bef.	After	Diff.
Brix	15.68	15.67	.01	15.77	15.76	.01	14.60	14.50	.10	15.61	15.60	.01	15.30	15.30	0
Pol.	14.23	14.18	.05	14.32	14.31	.01	13.29	13.26	.03	14.18	14.16	.02	13.89	13.88	.01
Sucrose	14.40	14.34	.06	14.48	14.47	.01	13.40	13.39	.01	14.25	14.24	.01	13.96	13.96	0
Glucose	.55	.59	.04	.53	.54	.01	.39	.40	.01	.34	.34	0	.30	.30	0
Apt. Pty.	90.75	90.49	.26	90.81	90.80	.01	91.03	91.45	.42	90.84	90.77	.07	90.78	90.72	.06
Gr. Pty.	91.84	91.51	.33	91.82	91.82	0	91.78	92.35	.57	91.29	91.28	.01	91.24	91.24	0
S/G	26.18	24.31	1.87	27.32	26.80	.52	34.36	33.48	.88	41.91	41.88	.03	46.53	46.53	0
S-P	.17	.16	.01	.16	.16	0	.11	.13	.02	.07	.08	0	.07	.08	.01
Phenol	.006	.012	.006	.002	.010	.008	.001	.006	.007	.002	.004	.006	.003	.002	.005
Litmus	.008	.002	.006	.010	.004	.006	.012	.005	.007	.014	.007	.007	.016	.008	.008
pH	8.44	7.25	1.19	8.76	7.51	1.25	8.89	7.76	1.13	9.00	8.01	.99	9.09	8.10	.99
Inversion	Positive			Doubtful			Doubtful			None			None		

Experiment 6 at 180° F.: Experiment 6 is also a quite alkaline series. Reactions of the different juices are fairly close to those of corresponding juices in the preceding experiments. The analyses of 1 show an increase of .02 in glucose

and decreases in purities and sucrose-glucose ratios. Inversion has been designated as "positive." In 2 the analyses indicate an increase of 0.01 in glucose and a decrease in the sucrose-glucose ratio but increases in apparent and gravity purities. This is another instance where comparisons indicate a probable error of 0.1 in brix, in the analysis after digestion. This juice has been classed as "doubtful." In 3, 4 and 5 there are no increases in glucose or other indications of inversion.

In this experiment inversion has been positively detected at .006 alkalinity to litmus and 7.17 pH. The least alkaline juice in which there was no evidence of inversion was .010 alkaline to litmus and 7.34 pH.

EXPERIMENT NO. 6 AT 180°.

	1 10 cc Lime			2 12.5 cc Lime			3 15 cc Lime			4 17.5 cc Lime			5 20 cc Lime		
	Bef.	After	Diff.	Bef.	After	Diff.	Bef.	After	Diff.	Bef.	After	Diff.	Bef.	After	Diff.
Brix	14.37	14.38	.01	14.15	14.05	.10	14.37	14.36	.01	14.57	14.53	.04	14.27	14.25	.02
Pol.	13.05	13.03	.02	12.91	12.92	.01	13.22	13.22	0	13.30	13.30	0	13.04	13.05	.01
Sucrose	13.15	13.13	.02	12.98	12.98	0	13.29	13.28	.01	13.35	13.34	.01	13.09	13.09	0
Glucose	.22	.24	.02	.17	.18	.01	.16	.16	0	.08	.08	0	.07	.07	0
Apt. Pty.	90.81	90.61	.20	91.24	91.96	.72	92.00	92.06	.06	91.28	91.54	.26	91.38	91.58	.20
Gr. Pty.	91.51	91.31	.20	91.73	92.38	.65	92.48	92.48	0	91.63	91.81	.18	91.73	91.86	.13
S/G	59.77	54.71	5.06	76.35	72.11	4.24	83.06	83.00	.06	16.68	16.67	.01	18.70	18.70	0
S—P	.10	.10	0	.07	.06	.01	.07	.06	.01	.05	.04	.01	.05	.04	.01
Phenol	.004	.006	.002	.003	.004	.001	.001	.003	.002	.001	.003	.004	.002	.001	.003
Litmus	.008	.006	.002	.010	.008	.002	.014	.010	.004	.018	.010	.008	.020	.011	.009
pH	8.13	7.17	.96	8.44	7.25	1.19	8.52	7.34	1.18	8.86	7.88	.98	9.03	8.10	.93
Inversion	Positive			Doubtful			None			None			None		

Experiment 7 at 180° F.: Juices 1, 2 and 3 in Experiment 7 show positive evidence of inversion while no definite indications are apparent in juices 4 and 5. The pH values are not available in this experiment on account of trouble with the hydrogen electrode. Inversion is found up to .006 alkalinity to litmus while at .008 alkalinity or above inversion is not indicated.

EXPERIMENT NO. 7 AT 180°.

	1 12.5 cc Lime			2 15 cc Lime			3 17.5 cc Lime			4 20 cc Lime			5 22.5 cc Lime		
	Bef.	After	Diff.	Bef.	After	Diff.	Bef.	After	Diff.	Bef.	After	Diff.	Bef.	After	Diff.
Brix	15.85	16.12	.27	15.91	15.94	.03	15.63	15.72	.09	16.00	16.01	.01	16.05	16.07	.02
Pol.	13.82	13.21	.61	13.37	13.31	.06	13.18	13.05	.13	13.57	13.57	0	13.64	13.65	.01
Sucrose	13.62	13.62	0	13.65	13.59	.06	13.37	13.29	.08	13.75	13.73	.02	13.74	13.75	.01
Glucose	1.20	1.28	.08	1.16	1.24	.08	1.08	1.13	.05	1.01	1.01	0	.93	.93	0
Apt. Pty.	84.04	82.00	2.04	84.04	83.50	.54	84.32	83.02	1.30	84.81	84.81	0	84.98	84.98	0
Gr. Pty.	85.93	84.49	1.44	85.80	85.26	.54	85.54	84.54	1.00	85.94	85.76	.18	85.61	85.56	.05
S/G	11.35	10.64	.71	11.77	10.96	.81	12.38	11.76	.62	13.61	13.60	.01	14.77	14.78	.01
S—P	.30	.41	.11	.28	.28	0	.19	.24	.05	.18	.16	.02	.10	.10	0
Phenol	.005	.011	.006	.001	.011	.010	.000	.013	.013	.001	.010	.011	.002	.008	.010
Litmus	.008	.006	.002	.009	.006	.003	.009	.005	.004	.010	.008	.002	.012	.009	.003
pH	8.01	...	...	8.18	...	...	...	...	...	...	...	...	...	...	...
Inversion	Positive			Positive			Positive			None			None		

Experiment 8 at 180° F.: Experiment 8, the final experiment at 180° F., is a less alkaline series than the four preceding experiments. All the initial juices are between neutrality to litmus and neutrality to phenolphthalein. All show evidence of inversion. This experiment is less consistent than most of the others. However, evidence of inversion is shown up to the most alkaline juices in the series: .005 alkalinity to litmus and 7.42 pH.

EXPERIMENT NO. 8 AT 180°.

	1			2			3			4			5		
	5 cc Lime			7.5 cc Lime			10 cc Lime			12.5 cc Lime			15 cc Lime		
	Bef.	After	Diff.	Bef.	After	Diff.	Bef.	After	Diff.	Bef.	After	Diff.	Bef.	After	Diff.
Brix	13.71	13.80	.09	13.82	13.89	.07	13.92	13.97	.05	13.83	13.92	.09	13.76	13.81	.05
Pol.	11.93	11.81	.12	12.07	12.10	.03	12.24	12.22	.02	12.15	12.13	.02	12.16	12.15	.01
Sucrose	12.05	11.97	.08	12.16	12.17	.01	12.32	12.29	.03	12.21	12.19	.02	12.21	12.20	.01
Glucose	.62	.72	.10	.60	.63	.03	.59	.60	.01	.54	.59	.05	.51	.57	.06
Apt. Pty.	87.02	85.58	1.44	87.34	87.11	.23	87.93	87.48	.45	87.85	87.14	.71	88.37	87.98	.39
Gr. Pty.	87.89	86.74	1.15	87.99	87.61	.38	88.51	87.97	.54	88.29	87.57	.72	88.74	88.34	.40
S/G	19.44	16.63	2.81	20.27	19.32	.95	20.88	20.48	.40	22.61	20.66	1.95	23.94	21.41	2.53
S—P	.12	.16	.04	.09	.07	.02	.08	.07	.01	.06	.06	0	.05	.05	0
Phenol	.020	.025	.005	.008	.013	.005	.004	.008	.004	.002	.007	.005	.001	.007	.006
Litmus	.006	.001	.005	.008	.002	.006	.010	.004	.006	.011	.005	.006	.012	.005	.007
pH	6.91	6.58	.33	7.60	7.01	.59	8.27	7.42	.85	7.34	7.34	...	7.42	7.42	...
Inversion	Positive			Positive			Probable			Positive			Positive		

Experiment 9 at 190° F.: Positive inversion is indicated in juices 1, 2 and 3 in Experiment 9 by comparatively large increases in glucose and decreases in purities and in sucrose-glucose ratios. There are no indications of inversion in 4. Analyses of 5 indicate an increase of 0.02 in glucose but no change in purities. We have hesitated to accept this as evidence of "probable" inversion for the following reasons: Purities do not confirm the indication. In previous experiments evidence of inversion has not been found in a more alkaline juice when a less alkaline juice has shown no evidence of inversion. Such a condition, however, is found in juices 4 and 5. The increase in glucose in 5 is not beyond the maximum limit of experimental error. It seems more probable that the increase in glucose is due to an irregularity in the analyses rather than that a detectable amount of inversion has taken place. This juice has been classed as "doubtful."

Inversion was positively indicated at .008 alkalinity to litmus and 7.25 pH while at .010 alkalinity and 7.68 pH no inversion was detected.

EXPERIMENT NO. 9 AT 190°.

	1			2			3			4			5		
	5 cc Lime			7.5 cc Lime			10 cc Lime			15 cc Lime			20 cc Lime		
	Bef.	After	Diff.	Bef.	After	Diff.	Bef.	After	Diff.	Bef.	After	Diff.	Bef.	After	Diff.
Brix	13.85	13.85	0	13.80	13.80	0	13.90	13.85	.05	13.82	13.80	.02	14.00	14.05	.05
Pol.	12.39	12.14	.25	12.42	12.27	.15	12.55	12.40	.15	12.40	12.38	.02	12.61	12.66	.05
Sucrose	12.40	12.19	.21	12.44	12.34	.10	12.56	12.45	.11	12.42	12.41	.01	12.61	12.66	.05
Glucose	.28	.46	.22	.27	.39	.12	.25	.37	.12	.20	.20	0	.10	.12	.02
Apt. Pty.	89.46	87.65	1.81	90.00	88.91	1.09	90.30	89.53	.77	89.73	89.71	.02	90.10	90.10	0
Gr. Pty.	89.53	88.02	1.51	90.15	89.42	.73	90.36	89.89	.47	89.87	89.93	.05	90.10	90.10	0
S/G	44.28	26.50	17.78	46.07	31.64	14.43	50.24	33.65	16.59	62.10	62.05	.05	126.1	105.5	20.6
S—P	.01	.05	.04	.02	.07	.05	.01	.05	.04	.02	.03	.01	0	0	0
Phenol	.021	.024	.003	.010	.014	.004	.004	.008	.004	.002	.006	.004	.003	.004	.007
Litmus	...	...	...	.008	.005	.003	.012	.008	.004	.016	.010	.006	.018	.012	.006
pH	6.64	6.41	.23	7.34	6.64	.70	8.69	7.25	1.44	8.86	7.88	1.18	9.03	7.88	1.15
Inversion	Positive			Positive			Positive			None			Doubtful		

Experiment 10 at 190° F.: In Experiment 10 inversion is positively indicated in juices 1, 2 and 3 by comparatively large increases in glucose and decreases in purities and sucrose-glucose ratios. Juice 4 has been classed as "doubtful" because of an increase of 0.01 in glucose without significant changes in purities. No change in glucose is indicated in 5 and the decreases in purity by themselves are hardly large enough to class this juice as doubtful. Positive inversion has been found at .010 alkalinity to litmus and 7.34 pH, while no inversion was detected at .014 alkalinity and 7.84 pH.

EXPERIMENT NO. 10 AT 190°.

	1			2			3			4			5		
	5 cc Lime			7.5 cc Lime			10 cc Lime			15 cc Lime			20 cc Lime		
	Bef.	After	Diff.	Bef.	After	Diff.	Bef.	After	Diff.	Bef.	After	Diff.	Bef.	After	Diff.
Brix	14.59	14.62	.03	14.63	14.60	.03	14.79	14.76	.03	14.63	14.60	.03	14.40	14.42	.02
Pol.	13.04	12.83	.21	13.08	12.87	.21	13.24	13.20	.04	13.12	13.08	.04	12.91	12.91	0
Sucrose	13.04	12.86	.18	13.10	12.87	.23	13.24	13.20	.04	13.12	13.10	.02	12.93	12.91	.02
Glucose	.41	.57	.16	.41	.55	.14	.37	.42	.05	.28	.29	.01	.17	.17	0
Apt. Pty.	89.40	87.76	1.64	89.41	88.15	1.26	89.52	89.43	.09	89.70	89.60	.10	89.66	89.53	.13
Gr. Pty.	89.40	87.96	1.44	89.54	88.15	1.39	89.52	89.43	.09	89.70	89.73	.01	89.79	89.53	.26
S/G	31.81	22.56	9.25	31.95	23.40	8.55	35.78	31.43	4.35	46.86	45.17	1.69	76.06	75.94	.12
S—P	0	.03	.03	.02	.00	.02	0	0	0	0	.02	.02	.02	0	.02
Phenol	.024	.027	.003	.012	.017	.005	.003	.008	.005	0	.007	.007	.003	.005	.008
Litmus	.001	.002	.003	.010	.006	.004	.016	.010	.006	.020	.011	.009	.022	.014	.008
pH	6.66	6.41	.25	7.42	6.58	.84	8.77	7.84	1.43	8.86	7.68	1.18	8.94	7.84	1.10
Inversion	Positive			Positive			Positive			Doubtful			None		

Experiment 11 at 190° F.: In Experiment 11, inversion is positive in juices 1, 2, 3 and 4. Glucose has increased 0.01 in juice 5 but increases in apparent and gravity purities are indicated. This is the third of the cases where an error in a brix determination is strongly indicated by a decrease of 0.1 in brix during digestion. Comparisons indicate that the error is in the analysis before digestion. Except for this error purities would probably confirm the indication of inversion shown by the glucose determinations. This juice, however, has been classed as "doubtful." Positive inversion has been found at .002 alkalinity to litmus and 7.10 pH while none of the juices remained alkaline enough to show signs of inversion.

EXPERIMENT NO. 11 AT 190°.

	1			2			3			4			5		
	5 cc Lime			7.5 cc Lime			10 cc Lime			12.5 cc Lime			15 cc Lime		
	Bef.	After	Diff.	Bef.	After	Diff.	Bef.	After	Diff.	Bef.	After	Diff.	Bef.	After	Diff.
Brix	15.10	15.26	.16	14.94	14.94	0	15.04	15.04	0	15.17	15.14	.03	15.10	15.00	.10
Pol.	12.96	12.56	.40	12.87	12.52	.35	12.96	12.85	.11	13.12	13.01	.11	13.02	12.98	.04
Sucrose	13.05	12.81	.24	12.97	12.71	.26	13.02	13.00	.02	13.16	13.12	.04	13.05	13.05	0
Glucose	.68	1.13	.45	.68	.96	.28	.66	.78	.12	.65	.72	.07	.59	.60	.01
Apt. Pty.	85.80	82.31	3.49	86.15	83.80	2.35	86.20	85.40	.80	86.50	85.93	.57	86.20	86.53	.33
Gr. Pty.	86.43	83.95	2.48	86.81	85.10	1.71	86.60	86.40	.20	86.75	86.67	.08	86.43	87.00	.57
S/G	19.19	11.34	7.85	19.07	13.24	5.83	19.73	16.67	3.06	20.25	18.22	2.03	22.12	21.75	.37
S—P	.09	.25	.16	.10	.19	.09	.06	.15	.09	.04	.11	.07	.03	.07	.04
Phenol	.014	.030	.016	.009	.022	.013	.005	.014	.009	.004	.012	.008	.003	.011	.008
Litmus	.003	.004	.007	.010	.002	.012	.014	.001	.015	.016	.002	.014	.018	.004	.014
pH	6.24	5.65	.59	6.80	5.81	.99	7.59	5.91	1.68	8.10	7.10	1.00	8.52	7.51	1.01
Inversion	Positive			Positive			Positive			Positive			Doubtful		

Experiments 12 and 13 at 200° F.: Experiment 12 is a single sample of juice clarified to a slight alkalinity to phenolphthalein and digested at 200° for 16 hours. Experiment 13 is another juice clarified to a slight acidity to phenolphthalein and digested for 22 hours. In both cases the development of acidity has been much greater than in experiments at lower temperatures, bringing the reactions slightly on the acid side of true neutrality and as would be expected material amounts of inversion were found.

EXPERIMENT NO. 12 AT 200°.

	Before	After	Diff.
Brix	14.19	14.13	.06
Pol.	12.48	12.19	.27
Sucrose	12.48	12.26	.22
Glucose	.50	.65	.15
Apt. Pty.	87.81	86.27	1.54
Gr. Pty.	87.95	86.77	1.18
S/G	24.96	18.86	6.10
S—P	.02	.07	.05
Phenol	.002	.015	.017
Litmus	.020	.004	.016
pH	9.02	6.95	2.07
Inversion		Positive	

EXPERIMENT NO. 13 AT 200°.

	Before	After	Diff.
Brix	15.10	15.11	.01
Pol.	13.90	13.39	.51
Sucrose	13.97	13.52	.45
Glucose	.25	.75	.50
Apt. Pty.	92.05	88.62	3.43
Gr. Pty.	92.52	89.48	3.04
S/G	55.88	18.08	37.85
S—P	.07	.18	.06
Phenol	.002	.009	.007
Litmus	.012	0	.012
pH	8.57	6.85	1.72
Inversion		Positive	

Experiment 14 at 200° F.: Owing to variation in temperature, which at times dropped as low as 195° F., the average temperature in Experiment 14 was slightly below 200° F. Reaction in the initial juices varied from a moderate alkalinity to litmus to neutrality to phenolphthalein. Development of acidity was much greater than at lower temperatures, the reactions of all the samples dropping below true neutrality.

Inversion is positively indicated in all cases.

EXPERIMENT NO. 14 AT 200°
(195-200)

	1—5 cc Lime			2—7.5 cc Lime			3—10 cc Lime			4—12.5 cc Lime			5—15 cc Lime		
	Bef.	After	Diff.	Bef.	After	Diff.	Bef.	After	Diff.	Bef.	After	Diff.	Bef.	After	Diff.
Brix	13.95	13.95	0	13.75	13.69	.06	13.61	13.63	.02	13.82	13.78	.04	13.60	13.61	.01
Pol.	12.58	12.27	.31	12.44	12.08	.36	12.42	12.02	.40	12.51	12.38	.13	12.39	12.28	.11
Sucrose	12.64	12.41	.23	12.51	12.18	.33	12.49	12.12	.37	12.56	12.47	.09	12.44	12.34	.10
Glucose	.41	.67	.16	.41	.65	.14	.41	.66	.15	.28	.37	.09	.20	.27	.07
Apt. Pty.	90.18	87.96	2.22	90.50	88.24	2.26	91.26	88.20	3.06	90.52	89.84	.68	91.11	90.23	.88
Gr. Pty.	90.61	88.96	1.65	91.00	89.00	2.00	91.77	88.92	2.85	90.90	90.50	.40	91.47	90.67	.80
S/G	30.83	18.52	12.31	30.51	18.74	11.77	30.46	18.36	12.10	44.86	33.70	11.16	62.20	45.70	16.50
S—P	.06	.14	.08	.07	.10	.03	.07	.10	.03	.05	.09	.04	.05	.06	.01
Phenol	.007	.015	.008	.004	.012	.008	.003	.013	.010	.003	.011	.008	0	.012	.012
Litmus	.008	.....	.....	.010	.....	.....	.011	.....	.....	.012	.....	.....	.014	.....	.....
pH	7.68	6.24	1.44	8.27	6.14	2.13	8.35	6.07	2.28	8.40	6.49	1.91	8.89	6.75	2.14
Inversion	Positive			Positive			Positive			Positive			Positive		

Experiment 15 at 212° F.: In Experiment 15 a sample of clarified juice was kept at the boiling point under a reflux condenser. Acidity developed rapidly. In six hours inversion is positively indicated. In twenty-two hours approximately a quarter of the total sucrose had been inverted.

At 200° and 212° F., development of acidity was so rapid that material quantities of sucrose were inverted even with initial reactions as alkaline as is at all desirable in factory practice. As it appeared impossible to maintain juices without inversion through the digestion period no further experiments were run at these higher temperatures.

EXPERIMENT NO. 15 AT 212°.

	Before	After 6 Hours	After 22 Hours
Brix	13.32	13.30	13.37
Pol.	10.40	10.28	7.13
Sucrose	10.63	.....	8.01
Glucose	1.60	1.66	4.26
Apt. Pty.	78.08	77.30	53.33
Gr. Pty.	79.81	.....	59.91
P/G	6.50	6.19	1.67
S/G	6.64	.....	1.88
Phenol.	.002	.....	.020
Litmus	.018	.....	.018
pH	8.80	6.58	5.22
Inversion		Positive	Positive

DEVELOPMENT OF ACIDITY

The preceding data indicates that development of acidity is such an important characteristic of juices at high temperatures that it is necessary to consider it before discussing inversion of sucrose or destruction of glucose. We would again note that reactions have been measured in three different ways: litmus titration, phenolphthalein titration, and hydrogen ion concentration. The first two are quantitative measurements, that is, measurements of total quantities of acid without particular reference to activity or ionization, as, in electrical measurements, watts measure the total quantity of current irrespective of its power to overcome resistance. Hydrogen ion concentration measurements refer only to that portion of the acid which is actually ionized or active without reference to the total quantity, as, again referring to electrical measurements, volts indicate ability to overcome resistance without reference to quantity.

Acid acts as a catalyzer in the hydrolysis of sucrose, that is, it causes the inversion of sucrose without being consumed. In such a reaction the degree of ionization or activity of the acid is of much greater importance than the quantity. However, as practically all data for acidity or alkalinity in factory practice are titration figures, we will first consider the development of acidity on this quantitative basis.

Development of total acidity at different initial reactions in the experiments at 180° F., on the basis of titration figures, is arranged graphically in Fig. 1. Higher temperatures have not been included, because data are not sufficient to bring out this relation.

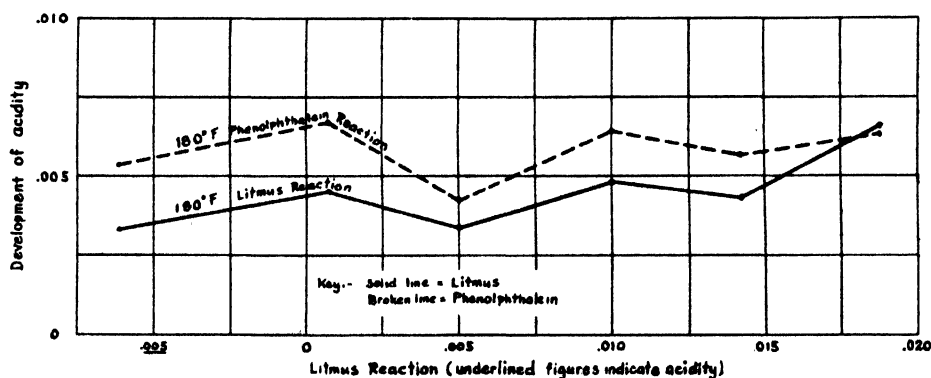


FIG. 1

The scale at the bottom is the litmus reaction of the juices before digestion. Juices with initial reactions within each range of .005, referred to litmus, have been averaged together and the points representing increases in acidity plotted on ordinates corresponding to this original litmus reaction. Development of acidity, indicated by phenolphthalein titration in the same juices, is plotted on the same ordinates. Development of acidity at different reactions, as shown by titration with either indicator, is indicated by the distances from the base line to the corresponding curve.

The curve for litmus titration indicates somewhat of a tendency toward greater development of acidity in the more alkaline juices. According to the phenolphthalein curve, however, there is little difference between alkaline and acid juices, and certainly no marked tendency towards greater development of acidity in the more alkaline juices.

Data from the preceding experiments on the effect of temperature on the development of total acidity during digestion are in the following tabulation. Both litmus and phenolphthalein titrations have been averaged together, as we wish to give a general idea of the effect of temperature, rather than to develop exact quantitative relations.

Temperature	No. of Determinations	Development of Acidity in 22 Hours
180° F.	80	.0054 per cent CaO
190° F.	29	.0074 " " "
200° F.	9	.0109 " " "
212° F.	2	.0270 " " "

Though the amount of data at 200° and 212° F. is comparatively small, the above figures are sufficiently conclusive to show that the rate at which total acidity develops is dependent on the temperature, increasing rapidly as the temperature increases.

Development of acidity on the more significant basis of hydrogen ion concentration has been plotted in Fig. 2. Data for 212° F. have not been included, as but one experiment is available at this temperature. In this experiment, the increase in hydrogen ion concentration per liter in twenty-two hours was .000,005 grams. To plot this point on the scale used, the graph would have to be extended to between nine and ten times its present height.

The curves for increase in hydrogen ion concentration in Fig. 2 show that at a given reaction the development of acidity increases with increases in temperature. At a given temperature, the more alkaline juices show the smallest development of acidity, while as acid reactions are approached development of acidity becomes very much greater. The curves are sufficiently conclusive to justify the latter conclusion notwithstanding irregularities in the curves for 190° F. and 200° F. In these curves increases in hydrogen ion concentration is less in the most acid juices than in the group of juices represented by the next point on the alkaline side. This may be significant, or it may be on account of the comparatively small amount of data available at these points. In this connection it might be noted that the hydrogen ion concentration curve for 180° F., representing a much greater amount of data, gives no indication of such an irregularity.

Though so far as we can judge from available publications, development of acidity has received little if any attention in investigations on juices, it has been generally recognized in factory practice. Here it has been sometimes ascribed to bacterial action but more often to the destructive action of lime on glucose.

Bacterial action can and does cause development of acidity at temperatures sufficiently low for bacteria to develop. It cannot be the cause at temperatures above the thermal limit of vegetative growth of the organisms found in juices. Temperatures in these experiments have been far enough above the latter point to preclude the possibility that bacterial action was a factor contributing to the development of acidity found.

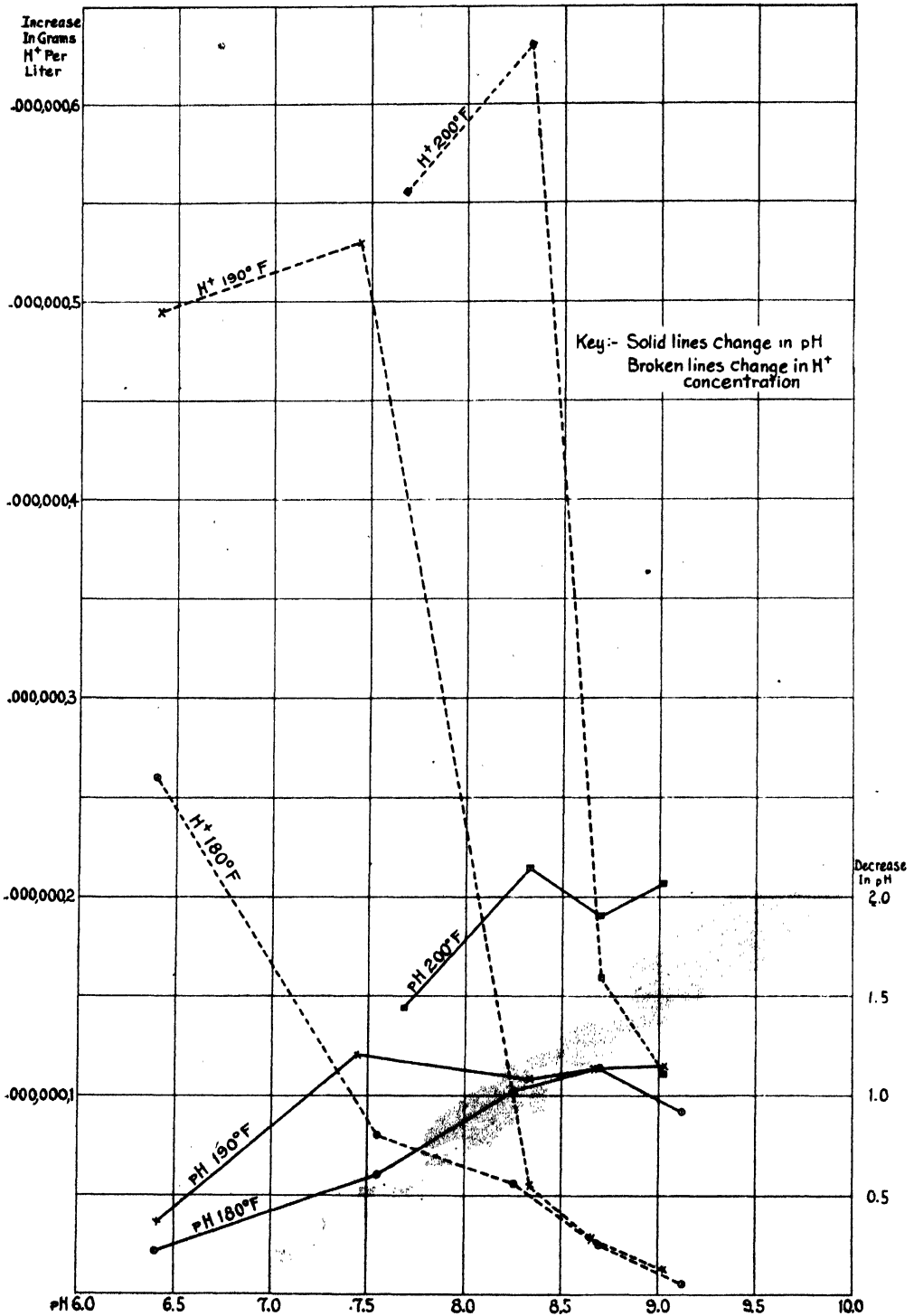


FIG. 2.

As in Fig. 1, juices with initial reactions within somewhat narrow ranges, have been averaged together. The scale at the bottom is the pH value of the juices before digestion. Solid lines are pH values after digestion, referred to the scale on the right. Distances of points on the solid lines above the base line thus indicate decreases in pH during twenty-two hours' digestion and the intersection of an ordinate on which a point is plotted with the base line is the pH of the juices represented by this point before digestion.

The pH units are logarithmic functions, used because of the awkwardness of actual

In the presence of large amounts of alkali, that is at very low hydrogen ion concentrations, without doubt glucose would be destroyed and at least a part of the development of acidity would be due to this factor. Here, however, we are considering the range of reactions covered by these experiments. This includes alkalinities up to 9 or 10 pH, which we consider as alkaline as it is necessary to consider when investigating cane sugar factory problems. References in this article to alkaline juices are to juices not exceeding this limit. Our data do not give us information on changes that may take place at abnormal alkalinities.

According to the theory that development of acidity is due to the formation of acid products, the result of the destructive action of lime on glucose, we would expect little or no development of acidity in acid juices, it being confined largely to alkaline juices and increasing with increase in alkalinity. The litmus curve in Fig. 1 does show a fairly pronounced tendency toward greater development of acidity in the more alkaline juices, and as litmus has been the indicator most frequently used in factory control, this may be a reason why the above theory has been so widely accepted. Contrary to what would be expected were this theory correct, the litmus curve in Fig. 1 indicates material development of acidity even in the most acid juices and the tendency towards greater development of acidity in the more alkaline juices is by no means as pronounced as would be expected. Further, the phenolphthalein curve shows this tendency to a slight extent only, if at all. Also to comply with this theory, glucose should be destroyed and of this there is very little evidence in these experiments. On the whole, titration figures in these experiments afford little, if any, confirmation for the theory that development of acidity is due to the destructive action of alkali on glucose.

On the more significant basis of hydrogen ion concentration, development of acidity, instead of being greater in the alkaline juices, is very much greater at acid reactions.

Research in the canning industry also has demonstrated that development of acidity at high temperatures is a characteristic of most, if not all, fruit and vegetable juices, taking place even when they have not been treated with alkali.

The theory that development of acidity in juices is due to the destruction of glucose by alkali can hardly be correlated with the above, so, within the range of reaction covered by these experiments, which includes the range practicable in factory operation, we have concluded that destruction of glucose is not the cause of development of acidity. Several possible causes have been considered, but so far we have failed to find an explanation in reasonable agreement with the observed facts.

Development of acidity is a factor which renders the investigation of such changes as inversion of sucrose and destruction of glucose in juices most difficult.

figures for hydrogen ion concentration. The difference between seven and eight pH is ten times the difference between eight and nine, the difference between six and seven is, in turn, ten times the difference between seven and eight. While the pH scale is very convenient for ordinary use, it is difficult to grasp the exact significance in a case such as is presented by this graph. In order to bring the exact relationship out more clearly, increases in hydrogen ion concentration are shown by dotted lines, referring to the scale on the left. Points on the dotted lines representing increases in hydrogen ion concentration are plotted on the same ordinates as corresponding points for decreases in pH.

We have so far been unable to devise methods for directly determining the rate at which sucrose is inverted at a given reaction, for we cannot maintain the juice at the desired reaction, and because of development of acidity, the rate of inversion is constantly changing as the experiment proceeds. Defining the exact reaction at which juices, from a standpoint of factory operation, may be considered safe from inversion, is rendered equally difficult by this factor. By the time sufficient sugar has been inverted to detect the change with available analytical methods, the juice has become more acid than the point at which, for practical purposes, inversion might be considered as starting. Development of acidity similarly affects obtaining accurate data on destruction of glucose, though in this case the change in reaction is such that the rate at which glucose is destroyed should decrease as the experiment proceeds instead of increasing as in the case of inversion of sucrose.

DESTRUCTION OF GLUCOSE

Changes in glucose occurred during the preliminary clarification of the samples. In some of the more acid juices, glucose increased, but at more alkaline reactions, glucose disappeared; destruction of glucose in some of the more alkaline samples amounting to a fairly large proportion of the glucose in the original juice. We are considering, however, destruction of glucose during the subsequent digestion of the clarified juices and not destruction of glucose during clarification.

A decrease in glucose is found in only one of the preceding experiments. This is juice 5 in Experiment 4, where the decrease is 0.02. As this decrease is hardly beyond the maximum experimental error, and as a number of other juices were digested at even higher alkalinities and at higher temperatures without decreases in glucose, we have hesitated to accept this single instance as positive evidence that glucose has been destroyed.

If any material amount of glucose has been destroyed, there should be losses of total sugars during digestion. The following are averages for total sugars before and after digestion in all experiments, after correcting for a slight amount of evaporation during digestion, and the effect of the formation of glucose on the density:

	Before Digestion	After Digestion
Sucrose	12.695	12.561
Glucose originally present	0.641	0.641
Increase in glucose (calculated back to sucrose) . . . . .	.....	0.136
Total sugars	13.336	13.338

According to these figures total sugars in the initial samples are fully accounted for in the samples after digestion.

Further evidence of a negative character are data for development of acidity previously discussed. Assuming that alkalinities would be reduced if glucose were destroyed by lime, data for development of acidity do not coincide with what would be expected if glucose had been destroyed through heat and excessive alkalinity.

From the above we can conclude that though glucose was in most cases destroyed during clarification there is no evidence that it was destroyed to an appreciable extent during further digestion under the conditions of these experiments even at initial reactions considerably more alkaline than the neutral point to phenolphthalein.

Nearly all of the juices in these experiments were of normal composition, but few of them containing more than 1 per cent glucose. The above conclusion does not preclude the possibility that detectable destruction of glucose might take place under the conditions of these experiments at high glucose concentrations, particularly at the higher temperatures.

INVERSION OF SUCROSE

Table 1 is a recapitulation of the more significant data in the preceding experiments on inversion of sucrose, as in the preceding tabulations decreases are in dark-face and increase in light-face figures. Reactions are expressed in pH values only, for after careful examinations it seems evident that the indications of both litmus and phenolphthalein titrations are so variable that they cannot be used as a basis for at all close conclusions as to the reactions at which inversion may be detected.

TABLE I.

Experiment	Temperature	Positive				Probable				Doubtful				Not Detected			
		Final pH	Change in Ap. Pty.	Change in Gr. Pty.	Change in Glucose	Final pH	Change in Ap. Pty.	Change in Gr. Pty.	Change in Glucose	Final pH	Change in Ap. Pty.	Change in Gr. Pty.	Change in Glucose	Final pH	Change in Ap. Pty.	Change in Gr. Pty.	Change in Glucose
1	180	7.68	.13	.21	.02	.....	.....	.....	.....	.....	.....	.....	.....	8.18	.09	.41	0
2	180	6.86	.30	.24	.04	.....	.....	.....	.....	.....	.....	.....	.....	7.25	.14	.21	.01
3	180	7.25	.20	.27	.04	7.51	.01	.20	.01	.....	.....	.....	.....	.....	.....	.....	.....
4	180	6.15	1.33	.79	.14	.....	.....	.....	.....	7.22	.43	.43	0	7.59	.06	0	.02
5	180	7.25	.26	.33	.04	.....	.....	.....	.....	7.51	.01	0	.01	8.01	.07	.01	0
6	180	7.17	.20	.20	.02	.....	.....	.....	.....	7.76	.42	.57	.01	.....	.....	.....	.....
7	180	.....	1.30	1.00	.05	.....	.....	.....	.....	7.25	.72	.65	.01	7.34	.06	0	0
8	180	7.42	.39	.40	.06	7.42	.45	.54	.01	.....	.....	.....	.....	.....	0	.18	0
9	190	7.25	.77	.47	.12	.....	.....	.....	.....	7.88	0	0	.02	7.68	.02	.05	0
10	190	7.34	.09	.09	.05	.....	.....	.....	.....	7.68	.10	.01	.01	7.84	.13	.26	0
11	190	7.10	.57	.08	.07	.....	.....	.....	.....	7.51	.33	.57	.01	.....	.....	.....	.....
12	200	6.95	1.54	1.18	.15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
13	200	6.85	3.43	3.04	.50	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
14	200	6.75	.88	.80	.07	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
15	212	5.22	24.7	19.9	4.26	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

The most alkaline juice in each experiment in which inversion has been designated as positive, has been tabulated under the heading "Positive." Similarly in an experiment in which inversion has not been detected, the least alkaline juice in which evidence of inversion has not been found is tabulated under the heading "Not Detected." All juices in which inversion has been designated as "Probable" and "Doubtful" are tabulated under the appropriate headings. The pH figures are for reactions at the end of the digestion period.

Definite conclusions as to the reaction at which detectable inversion may be found can hardly be drawn from data in the "Positive" column for in all cases, except two, inversion has proceeded considerably further than what we have accepted as minimum evidence of positive inversion. This is particularly true of the experiments at 200° and 212° F. where the pH has dropped below 7 and considerable inversion has taken place. Six out of eight of the juices in experiments at 180° and 190° F. tabulated in this column are more alkaline than 7 pH. The particular significance of data in this column is that inversion occurred before the juice had decreased in alkalinity to the true neutral point.

Considering next the least alkaline juices in which the analyses failed to detect evidence of inversion, we find one at 7.25 pH, one at 7.34 pH and the remainder between 7.5 pH and 8.2 pH. The particular significance of data in this column is that at higher alkalinities inversion has not been detected. It is improbable that evidence of inversion will be found in juices held at high temperatures before the alkalinity decreases to below 8 pH.

In the "Probable" column we find fairly definite evidence of inversion at 7.42 pH and 7.51 pH. In the "Doubtful" column which includes juices in which analyses have shown some evidence of inversion, though not to the extent that a conclusion that it had been detected seems justified on the strength of single analyses, pH values vary from 7.22 to 7.88. On the whole, it seems reasonable to conclude that by the time a juice is held at high temperatures till the alkalinity has dropped to a point within this range, evidence of inversion should begin to appear.

The most significant features of data in this table, which we wish to particularly emphasize, are: First, inversion has been positively demonstrated in juices alkaline to litmus and on the alkaline side of true neutrality. Second, at still higher alkalinities, although still on the acid side of neutrality to phenolphthalein inversion has not been detected.

Where data can be averaged and plotted more reliable deductions may be drawn than from tabulated data such as in Table 1. Experiments at 180° and 190° F., taken together furnish sufficient data to secure reasonably satisfactory averages notwithstanding difficulties inherent in obtaining valid averages of this kind of data. These are plotted in Fig. 3, where changes in glucose in experiments at 180° and 190° F. are plotted against pH values after digestion. Hydrogen ion concentrations, expressed in grams per liter, designated H^+ are also given beneath the corresponding pH. Average points at which neutrality to litmus and the faintest detectable pink color with phenolphthalein have been observed in juices are also indicated. The curve gives a slight indication of inversion as high as 8 pH but no indication that inversion has taken place at still higher alkalinities. At 7.5 pH the indication becomes quite definite. At still lower pH values the amount of inversion increases rapidly.

Two theories relating to inversion of sucrose have been quite generally accepted in the cane sugar industry. The first is that inversion through acidity does not take place at moderate acidities. The second is that inversion is caused by heat independent of acidity.

We are unable to trace the origin of the first of the above theories and so do not know in what sense the term acidity is used; that is, whether it refers to

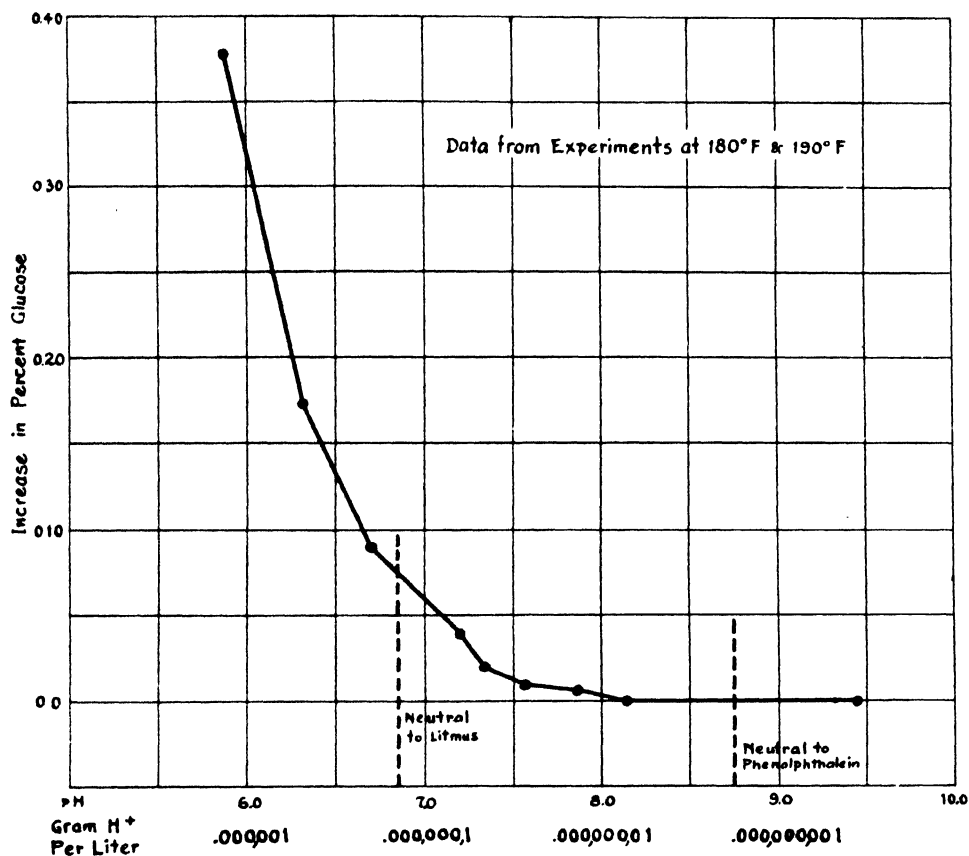


FIG. 3.

litmus, to phenolphthalein, or to other indicators. If phenolphthalein is referred to, the theory has some foundation in fact, for within a narrow range on the acid side of the neutral point to phenolphthalein in juices inversion, if occurring at all, takes place to such a slight extent that we were unable to detect it in these experiments. In factory practice, this theory has been quite generally accepted as referring to litmus. On this basis, data we have presented demonstrate that it is most misleading, detectable inversion being found not only in juices alkaline to litmus but also in juices on the alkaline side of true neutrality.

The theory that inversion of sucrose is caused by heat appears to have its origin in work on unbuffered solutions, in connection with which hydrogen ion concentration measurements were not made. Sugar in common with most organic substances is destroyed at sufficiently high temperatures. If inversion through heat occurs at temperatures below the boiling point it should have been found in the more alkaline juices in these experiments. As inversion was not detected in these juices we have concluded that within the range of temperatures covered by these experiments, the theory that "heat" causes any material inversion of sucrose in juices is without foundation.

Scientific investigation has demonstrated that in unbuffered or lightly buffered solutions, within the range of hydrogen ion concentrations covered by these experiments and at a given concentration of sucrose, inversion is approximately

proportional to the hydrogen ion concentration. This theory might be visualized by considering the hydrogen ions and sucrose molecules in motion in a solution and inversion occurring in proportion to the number of collisions between the two.

The above theory agrees well with the results secured in these experiments. Indeed it is difficult to account for what has been found on any other basis. The modern conception of neutrality is that hydrogen and hydroxyl ions are present in equal concentrations, not the absence of ions. In passing from neutrality to alkalinity, that is from 7 to higher pH values, there is an increase in the hydroxyl ion concentration and a corresponding decrease in the concentration of hydrogen ions. This decrease is in quantity. There is little reason to believe that the activity of the remaining hydrogen ions is changed. On this basis we have a satisfactory explanation of the inversion noted in alkaline juices.

The curve in Fig. 3 also supports this theory. While increases in glucose are plotted against final, and not average reactions, when we take into consideration the more rapid increase in hydrogen ion concentration as acid reactions are approached, average reactions during the digestion period may be somewhat roughly inferred. On this basis there is a sufficiently consistent relation between inversion and hydrogen ion concentration to lend considerable support to the theory that inversion of sucrose is in proportion to hydrogen ion concentration.

SUMMARY

We are not so interested in developing theories, however, as in obtaining reliable information on which to base factory practice. From this point of view these data on the characteristics of hot clarified juice may be summed up as follows:

First: Development of acidity is constantly taking place. Increase in hydrogen ion concentration is much more significant from the standpoint of factory operation than quantitative development, shown by titration figures. Increase in hydrogen ion concentration is at a minimum velocity at higher alkalinities and lower temperatures, the velocity increasing as alkalinities are reduced and also as temperatures are increased.

Second: Though glucose is destroyed when juices are clarified at alkaline reactions, further destruction of glucose to a detectable extent does not take place on further digestion under the conditions of these experiments.

Third: Inversion of sucrose takes place at high temperatures in moderately alkaline juices. At still higher alkalinities we have not been able to detect it. It seems quite probable, however, that under otherwise equal conditions, inversion of sucrose is in proportion to hydrogen ion concentration.

We have previously noted that from the standpoint of raw sugar factory operation, a "neutral zone" might be defined as a range of reactions where sucrose is not inverted and glucose is not destroyed; or if these changes take place at all they proceed slowly enough so that their effect is negligible. It was also pointed out that in juices such a zone must be at temperatures above 160° or 165° F. because at lower temperatures bacteria can develop and destroy both glucose and sucrose as any reaction practicable in raw sugar factory practice.

The following discussion of such a zone is with reference to that portion of the process to which the results of this investigation are directly applicable. This is from the juice heaters until lower temperatures and higher concentration are reached in the evaporators. These data are not so directly applicable beyond the evaporators where higher concentrations, lower temperatures, and volatilization of acid products from boiling liquors introduce factors not taken into consideration in these experiments.

Destruction of glucose has not been demonstrated, so with reference to this factor, at least in juices of moderate glucose content, the neutral zone may extend to the limit of alkalinity covered by these experiments. This is at least 9.5 pH.

If inversion of sucrose is in proportion to hydrogen ion concentration a zone in which no inversion of sucrose takes place will not be found. On the basis of the curve in Fig. 3, however, it would appear that above 7.8 or possibly 8.0 pH, inversion proceeds so slowly that it may be considered negligible, while at a more acid reaction than this it becomes appreciable. We, therefore, tentatively define a "neutral zone" in which destruction of both sucrose and glucose is negligible as from about 7.8 pH to the limit of alkalinity covered by these experiments.

The above has been qualified as tentative for the following reasons:

First: These experiments were planned primarily to obtain a general idea of the characteristics of hot clarified juice. On account of developments of acidity the methods employed have not been suitable for obtaining data enabling us to calculate the rate of inversion at a given reaction. It has been necessary to form an opinion as to the reaction where inversion becomes negligible from the amount of inversion found at the end of an experiment in which the reaction was constantly changing. In this connection we would note that an increase of 0.01 in glucose is equivalent to the destruction of slightly less than 0.1 per cent of the sucrose in a juice.

Second: Data at 200° and 212° are incomplete. There were very few experiments at these temperatures because it was impossible to carry juices through the digestion period without inversion. Inversion of sucrose is much faster at higher temperatures. Deerr gives the following figures for the effect of temperature on the rate of inversion: *

Temperature ° C	Relative Inversion Rate
25	1
50	26.7
70	282
80 (176° F.)	814
90 (194° F.)	2110
100 (212° F.)	5659

Without doubt temperature has a similar influence on the rate at which glucose is destroyed. More accurate information on inversion rates at given hydrogen ion concentrations and at higher temperatures, which is now being secured, may render it necessary to modify to some extent the above limits of the neutral zone.

* Cane Sugar, page 262.

While destruction of glucose does not impose an alkaline limit on our neutral zone, in factory practice another consideration definitely limits the alkalinity. Previous work on clarification has shown that the maximum purification is secured when the juice, after it has passed through the heater, is approximately 8.6 pH to 8.8 pH. Additions of lime beyond this point cause undesirable decreases from the maximum purity.

If juices are clarified at the optimum reaction there is a margin of about one point pH for development of acidity before reactions are reached where appreciable inversion need be feared. How much the acidity develops depends on how high the temperatures are and how long the juice is subjected to these high temperatures. Under ordinary operating conditions juices clarified at the optimum reaction can be worked through to where lower temperatures are encountered in the evaporators before the reaction drops to 7.8 pH. In this case no appreciable inversion will be sustained in this part of the process. If the reaction becomes more acid than this it is practically certain that some inversion will take place.

In many factories the large volume of settlings resulting from an alkaline clarification overloads the filtration equipment and prevents lining to the optimum reaction. This is particularly true when the juices worked are those from which it is possible to secure the best results in clarification. If the reaction of the heated juice is below the lower limit of the "neutral zone," appreciable inversion is undoubtedly going on from the time the juice leaves the heater. It must also be remembered that development of acidity is faster in such juices than in those clarified at a more alkaline reaction. Under such conditions some loss appears inevitable. It may be reduced to the extent that temperatures can be lowered and the time juices are exposed to high temperatures shortened. These expedients, however, are probably of limited application.

Results secured in these experiments may be applied directly to the problem of keeping juices without loss during shutdowns. Except that in these experiments, temperatures were constant while in the settling tanks temperatures are dropping, conditions during these experiments are identical with those when juices are held over. The principal factors which must be considered are two: bacterial action and development of acidity. The tanks must be sufficiently well insulated so that temperatures in all parts of them are maintained above 160 to 165 degrees. If it drops below this, losses through bacterial action may be expected. Development of acidity must be retarded by reducing the temperature at which the tanks are filled. If the juice is limed so that the hot juice is about 8.6 to 8.8 pH and the temperature is low enough so that the pH does not fall below a point somewhere between 7.5 and 8.0, losses will be negligible. This fully confirms and explains H. S. Walker's observations at Pioneer Mill. The temperature drop in the settling tanks at this factory averaged .5° F. per hour. By liming the juice to about the optimum reaction and filling the tanks at 180° F., juice could be held for 24 or 36 hours without appreciable loss.

While the results of this investigation on the whole are at variance with many of the usually accepted theories in cane sugar factory practice, they are thoroughly

in agreement with the time-honored axiom that sugar should be worked through the process as rapidly as possible.

Further work to secure quantitative data of greater precision is now being carried on in this laboratory on the basis of the general characteristics herein developed. All our investigation of clarification, particularly that presented in this article, strongly indicates the need of better means for controlling reactions in factory practice. Developing methods for determining hydrogen ion concentration, so that it will be practicable to use them in routine factory work, is included in the work now being carried on.

Weeding Railroad Tracks in the Tropics*

By R. E. VANDERBILT

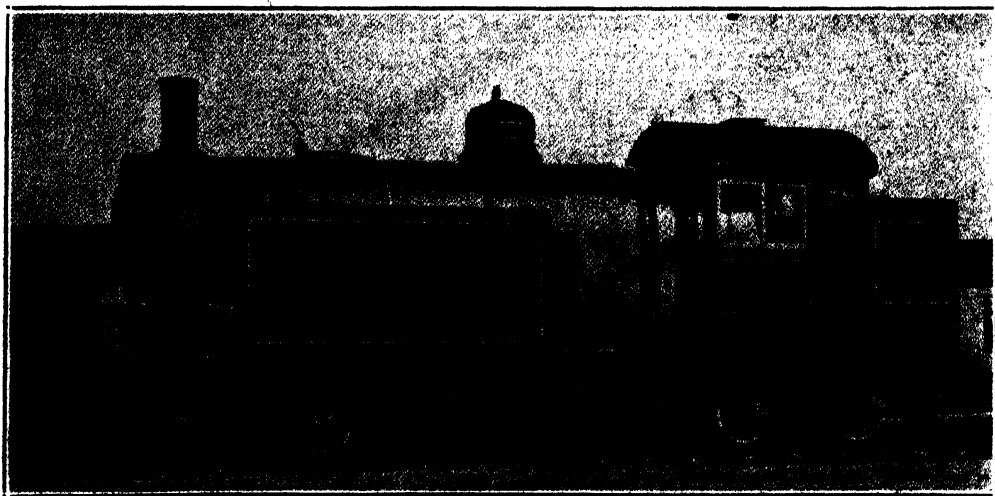
One of the important matters to which almost every railroad must devote attention in a greater or less degree is that of keeping its right of way cleared of vegetation; that is, of grass and weeds, which often seem determined to grow where they are least wanted. The roads operating in our temperate zones spend annually large sums in cleaning their tracks, but in the tropics, where the weather is always warm or hot and the rains copious, the problem assumes much greater proportions. In the earlier days of railroading all the weeding was done by laborers who either plucked the vegetation out by hand or scratched it out with hoes and shovels; and even now this method is used by most roads throughout the world.

However, it is of interest to note that within the last few years, certain roads have by study and experimentation developed other methods of weeding that are far more effective and economical than the hand method. These new processes, which are successful in varying degrees according to local conditions, fall generally into three classes as follows: chemical, fire and superheated steam. The chemical process consists in spraying the vegetation with a poisonous solution which causes it to wither and fall to the ground, while the apparatus used includes a suitable car fitted with tanks, spraying device and the necessary control apparatus. The fire process, as the name we have given it implies, involves the burning of the weeds and grass with an oil fire supplied with fuel from a tank and spraying feature located on a special car. The superheated steam process depends, for its effect, upon subjecting the vegetation to a storm of highly superheated steam, usually with a temperature of 700° F. or more, which penetrates to the roots. To do this requires a boiler and superheater of liberal capacity, properly mounted on a car with water and fuel space. All three types of apparatus depend upon a locomotive for their movement.

In the United States, perhaps the most popular process is the chemical, although it is rightfully objected to in many regions because of the deaths result-

*From *Baldwin Locomotives*, April, 1924.

ing among livestock which eat the poison-covered weeds, this mortality rate often far exceeding that due to the striking of the animals by passing trains. However, there are many other regions in which this objection does not exist, because of the variety of our industries in different parts of the country. The fire process, being less effective as a permanent weed destroyer and more injurious to wooden ties, is comparatively little used, notwithstanding it is a cheaper method than hand weeding. The superheated steam weed destroyer, being the most effective of the three methods and the least injurious to livestock and the wooden ties, finds greatest favor where these features are most required; namely, on the tropical railroads where track vegetation grows tall and strong and also very rapidly; where cattle, goats and horses graze almost without restriction, and where the exposed ties offer so much chance to destroy the track by fire. This last statement leads us to the thought suggested in our title, which is, to give a short discussion of how one or two tropical companies are using superheated steam most successfully, and to describe some apparatus recently built for the purpose.



Side view of weed destroyer in use by Cuba Northern Railway Company.

To the railway operating officials of the United Fruit Company in Panama, Costa Rica, Honduras and Cuba belongs most of the credit for the development of a cheap weeding process in the tropics. These men, whose duty it is to transport from the interior farms and plantations to the seaports the fruits and sugar produced, faced the problem of cleaning many miles of track and have solved it to the extent that each year now with the superheated steam destroyers show a vast saving over the years when hand cleaning was resorted to. For example, the Northern Railway Company of Costa Rica reported in 1922 that their yearly cost per mile for hand weeding had been \$82.50, while the corresponding cost with superheated steam was \$13.92, showing a saving of \$68.58 per mile per year or about 83 per cent of the cost for hand weeding. Equally pleasing results have been accomplished by the Truxillo Railway in Honduras who reduced their cost of \$49.20 per kilometer to about \$3.00 per kilometer.

For the most part the apparatus used by these roads has been made by their own shop forces from parts already on hand or purchased from the Baldwin Locomotive Works. It has been shown possible to operate a weed destroying train satisfactorily with one engineer, one fireman, two brakeman, and one night hustler, this crew handling both the weed burner and the locomotive propelling it. The men sleep in a camp car which is carried along, and eat at the most convenient places along the line. At night the entire staff ties up at the nearest siding. The speed of travel is usually 2 miles per hour for the best results.

The accompanying photographs illustrate an apparatus recently built by the Baldwin Locomotive Works for use on the lines of the Cuba Northern Railways Co. As can be seen, the boiler is of the locomotive type, firmly anchored to a saddle casting at the front and supported on expansion pads at the back end, with superheater built in as in locomotive practice. A fuel oil tank is provided at the rear of the car while water tanks appear at either side of the boiler barrel. Feed water is handled by two injectors, which discharge into the boiler through a double top check. Draft is induced by means of an efficient brass nozzle in the smoke box directing a jet of steam upward through the cleaning pipe and stack with its control permitted by an ordinary blower valve in the cab.



Truxillo Railroad Company's Weed Destroyer Under Steam Test.

To support and carry the weight of this liberal sized boiler, as well as the water and fuel tanks, a flat car of sturdy construction had to be furnished. Structurally, the underframe includes center sills of 15", 70 lb. eye beams and side sills of 12", 50 lb. channels, strongly braced. The trucks likewise are for heavy duty, having 6" x 11" journals and 33" rolled steel wheels. The equipment covers such refinements as roller side bearings for the trucks, combined air and hand brake, and spring draft gear.

The actual spraying of the superheated steam over the weeds and grass is accomplished by the large, square, pan-shaped part shown suspended from the car frame between the two trucks. Briefly, this part, known as the grid, consists of a series of $\frac{3}{4}$ " iron pipes, symmetrically spaced and perforated for the direc-

tion of the steam down to the roots of the vegetation. After leaving the main throttle in the boiler dome the steam passes through the dry pipe and superheater, through steam pipes in the smoke box and saddle casting, hence through three flexible branch pipes in the grid. As to discharge arrangement, the grid is divided into three sections, one lying between the rails, another outside of the right hand rail and the third outside of the left hand rail. Each of these sections receives its steam through a separate branch pipe from the main supply so that by means of stop cocks in the branch pipes which are operated with levers in the cab, it is possible to burn the weeds selectively, according to where the greatest need appears. Naturally it is important to retain as much heat as possible in the steam until it actually leaves the grid, and to accomplish this all open supply pipes as well as the top of the grid itself, are heavily lagged with asbestos. Also, to aid in confining a large quantity of hot steam over the area, the builders provided an extra heavy canvas curtain which, though not shown in the photo, is arranged for hanging around the outside of the grid.

Much interest is being shown in the apparatus by tropical railroads and a rapid adoption of it as standard equipment in the future is predicted.

[H. P. A.]

Sugar Prices

96° Centrifugals for the Period

June 16 to September 12, 1924.

	Date	Per Pound	Per Ton	Remarks
June	16, 1924.....	5.2133¢	\$104.27	Porto Ricos, 5.15, 5.28; Philippines, 5.21.
"	17.....	5.215	104.30	Cubas, 5.15; Philippines, 5.28.
"	19.....	5.28	105.60	Cubas.
"	26.....	5.34	106.80	Cubas.
"	27.....	5.37	107.40	Cubas, 5.40; Porto Ricos, 5.34.
"	30.....	5.34	106.80	Philippines.
July	1.....	5.28	105.60	Spot Philippines.
"	2.....	5.21	104.20	Spot Philippines.
"	7.....	5.15	103.00	Porto Ricos.
"	9.....	5.055	101.10	Spot Cubas, 5.09; Spot Philippines, 5.02.
"	10.....	5.09	101.80	Philippines.
"	14.....	5.15	103.00	Porto Ricos.
"	15.....	5.18	103.60	Cubas, 5.21; Porto Ricos, 5.15.
"	17.....	5.02	100.40	Cubas.
"	23.....	5.055	101.10	Cubas, 5.02; Philippines, 5.09.
"	24.....	5.15	103.00	Spot Cubas.
"	28.....	5.09	101.80	Philippines.
"	31.....	5.02	100.40	Cubas.
Aug.	6.....	5.055	101.10	Cubas, 5.02, 5.09.
"	7.....	5.12	102.40	Cubas.
"	11.....	5.18	103.60	Philippines, 5.15; Cubas, 5.21.
"	12.....	5.21	104.20	Cubas.
"	14.....	5.28	105.60	Cubas.
"	15.....	5.40	108.60	Cubas.
"	18.....	5.4933	109.87	Cubas, 5.46, 5.53, 5.49.
"	19.....	5.46	109.20	Cubas.
"	20.....	5.53	110.60	Cubas.
"	26.....	5.495	109.90	Cubas, 5.46, 5.53.
"	28.....	5.65	113.00	Spot Cubas.
Sept.	3.....	5.78	115.60	Cubas.
"	8.....	5.90	118.00	Cubas.
"	9.....	5.93	118.60	Cubas, 5.90, 5.96.
"	10.....	6.03	120.60	Cubas.
"	12.....	5.96	119.20	Cubas.

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